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(54) **PROXY SERVER ASSOCIATED WITH A MOBILE CARRIER FOR ENHANCING MOBILE TRAFFIC MANAGEMENT IN A MOBILE NETWORK**

(71) Applicant: **Seven Networks, Inc.**, San Carlos, CA (US)

(72) Inventor: **Rami Alisawi**, Kerava (FI)

(73) Assignee: **Seven Networks, Inc.**, San Carlos, CA (US)

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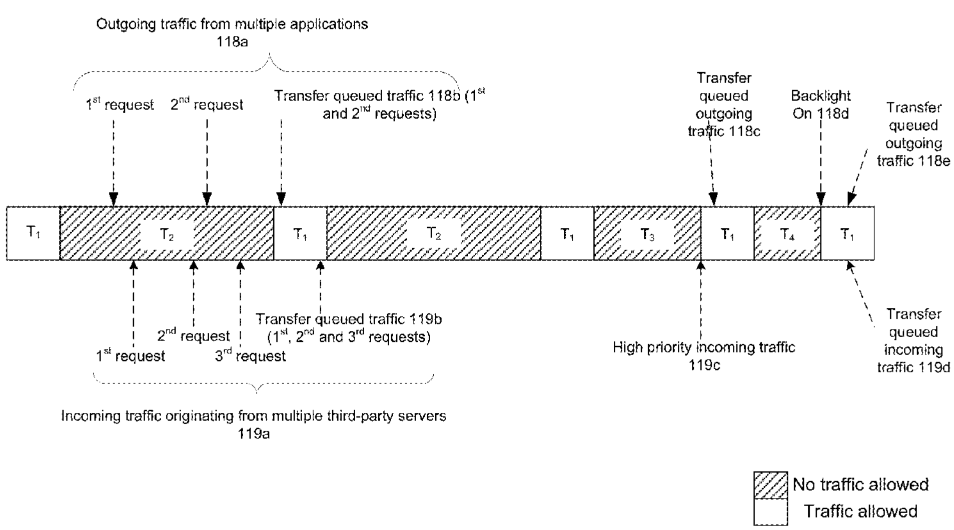
Primary Examiner — Steven H Nguyen
(74) *Attorney, Agent, or Firm* — NKK Patent Law, PLLC

(57) **ABSTRACT**

A proxy server or component associated with or residing on a mobile carrier or mobile operator side for enhancing mobile traffic management in a mobile network and system and methods therefor are disclosed. The proxy server, in some embodiments, can delay, clump, block or otherwise manage incoming traffic initiated by one or more application servers and directed to one or more mobile applications associated with the one or more applications servers installed on a mobile device. The proxy server can manage the incoming traffic based on traffic category, time criticality, priority and/or other criteria. The proxy server can further transfer the traffic that was delayed to the mobile device in response to a trigger such as promotion of a radio state on the mobile device or a start of an interval for transferring incoming to the mobile device and outgoing traffic from the mobile device.

23 Claims, 18 Drawing Sheets



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U.K. Patent Application No. GB1300808.1, Examination Report, 10 pages, Mar. 11, 2013.
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U.K. Patent Application No. GB1318437.9, Examination Report, 7 pages, Feb. 6, 2014.
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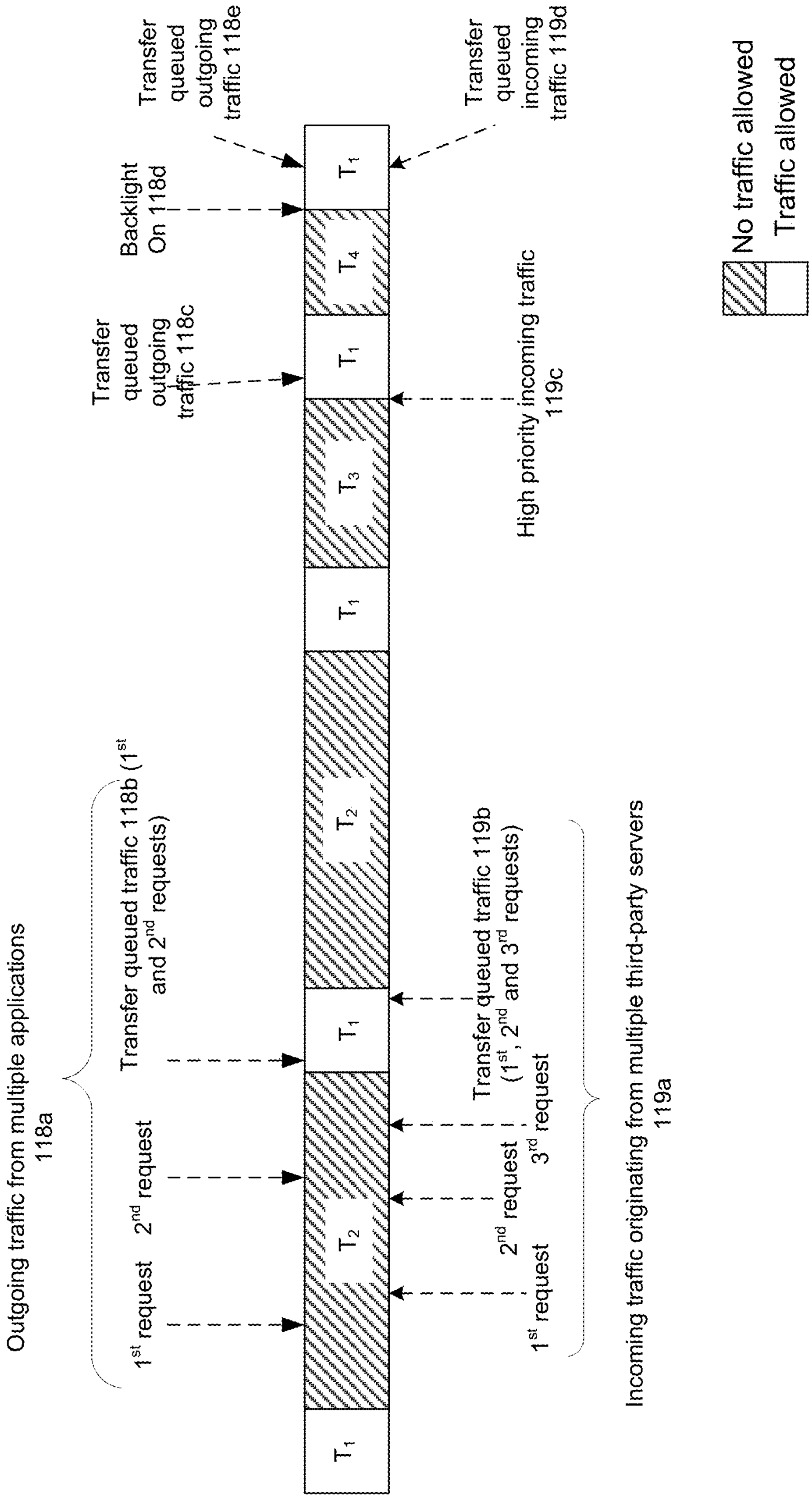

Outgoing traffic from multiple applications 118a
1st request
2nd request
Transfer queued traffic 118b (1st and 2nd requests)
Transfer queued outgoing traffic 118c
Backlight On 118d
Transfer queued outgoing traffic 118e
Transfer queued incoming traffic 119d
High priority incoming traffic 119c
Transfer queued traffic 119b (1st, 2nd and 3rd requests)
1st request
2nd request
3rd request
Incoming traffic originating from multiple third-party servers 119a
T1
T2
T1
T2
T1
T3
T1
T4
T1
No traffic allowed
Traffic allowed

FIG. 1A

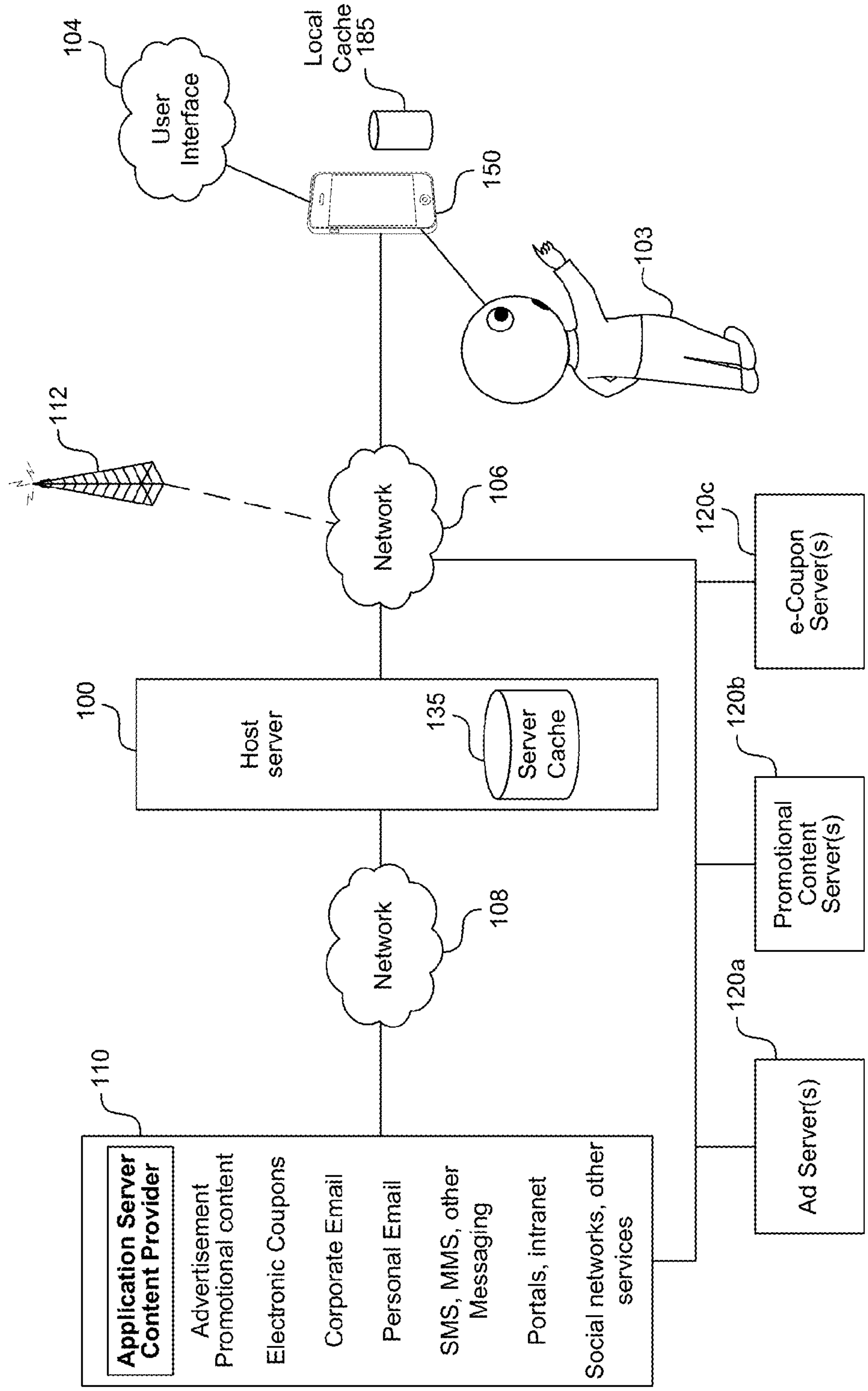

104
User Interface
Local Cache 185
150
112
103
Network
106
100
Host server
135
Server Cache
Network
108
120c
e-Coupon Server(s)
120b
Promotional Content Server(s)
120a
Ad Server(s)
110
Application Server Content Provider
Advertisement Promotional content
Electronic Coupons
Corporate Email
Personal Email
SMS, MMS, other Messaging
Portals, intranet
Social networks, other services

FIG. 1B

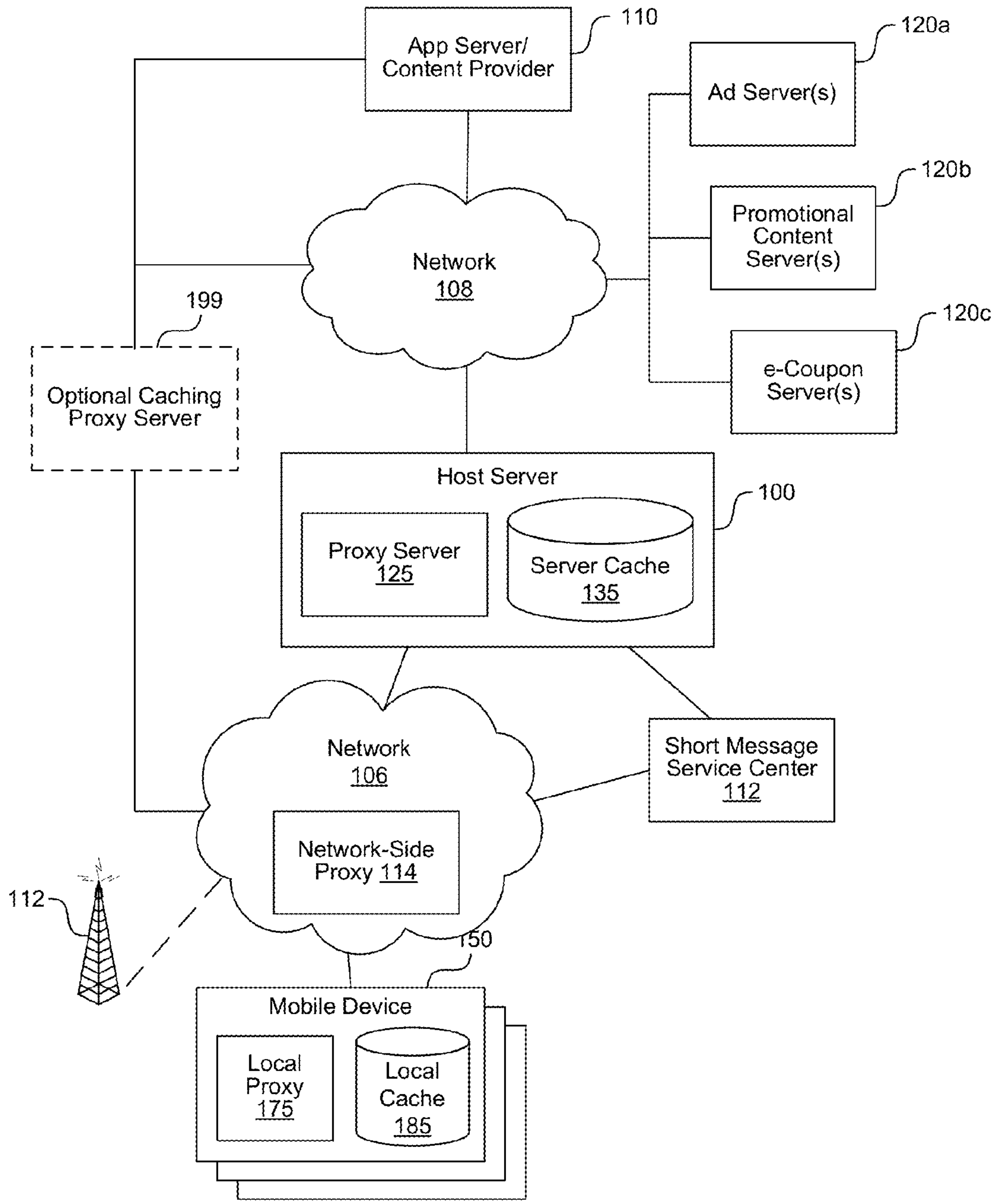

App Server/ Content Provider
110
Ad Server(s)
120a
Promotional Content Server(s)
120b
e-Coupon Server(s)
120c
Network
108
199
Optional Caching Proxy Server
Host Server
100
Proxy Server
125
Server Cache
135
Network
106
Network-Side Proxy 114
Short Message Service Center
112
112
150
Mobile Device
Local Proxy
175
Local Cache
185

FIG. 1C

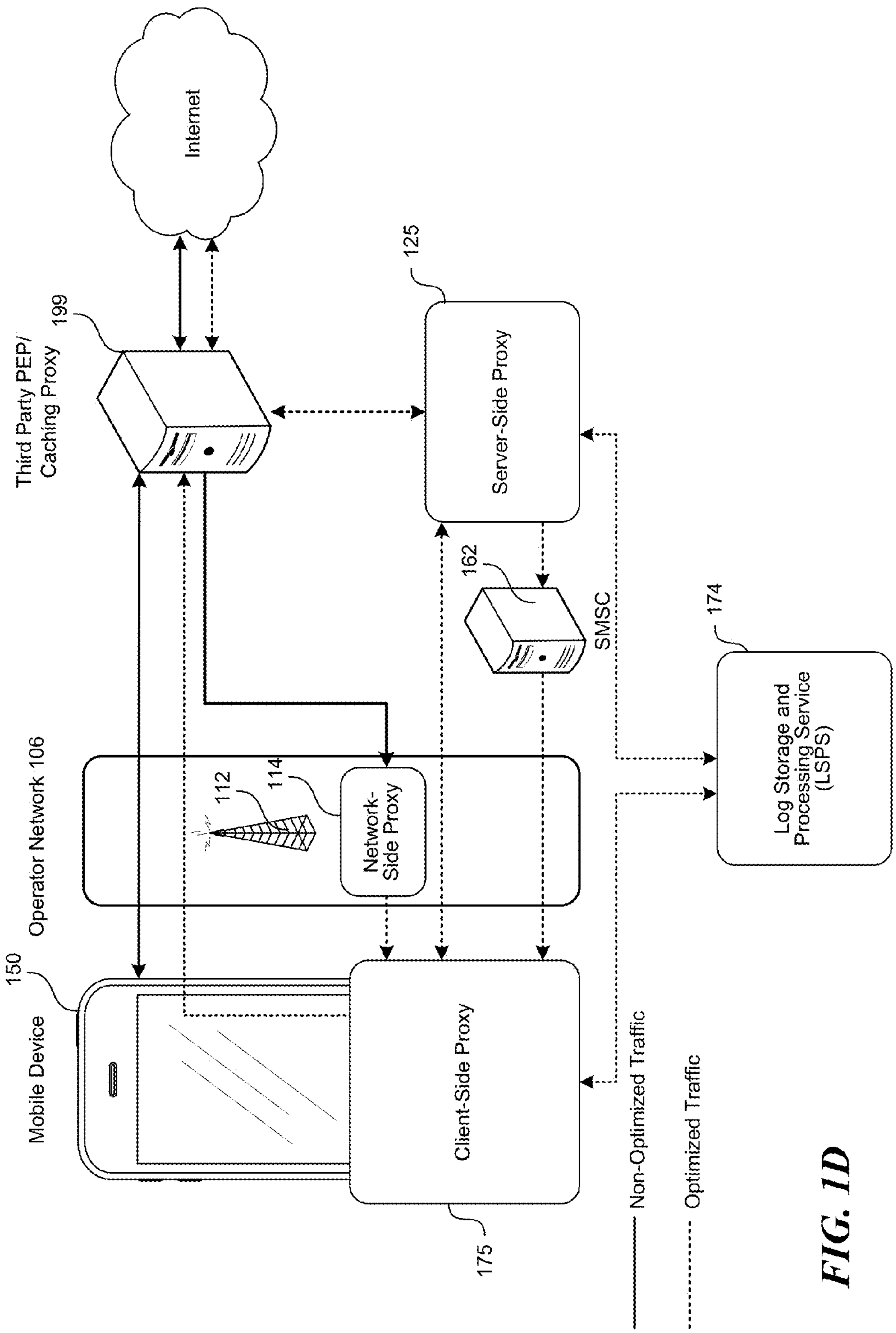

Internet
Third Party PEP/
Caching Proxy
199
125
Server-Side Proxy
162
SMSC
174
Log Storage and
Processing Service
(LSPS)
Operator Network 106
112
114
Network-
Side Proxy
Mobile Device
150
Client-Side Proxy
175
Non-Optimized Traffic
Optimized Traffic

FIG. 1D

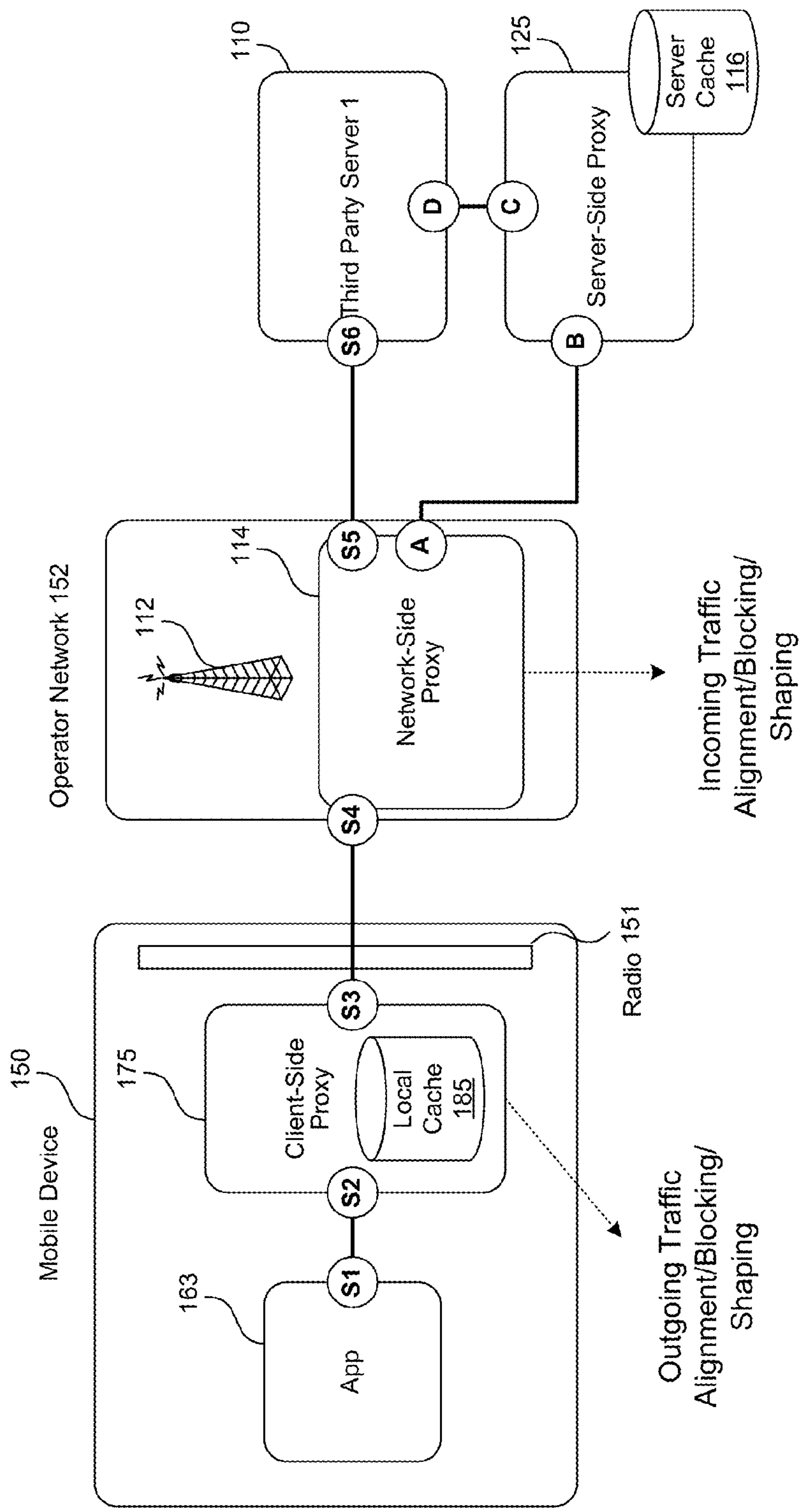
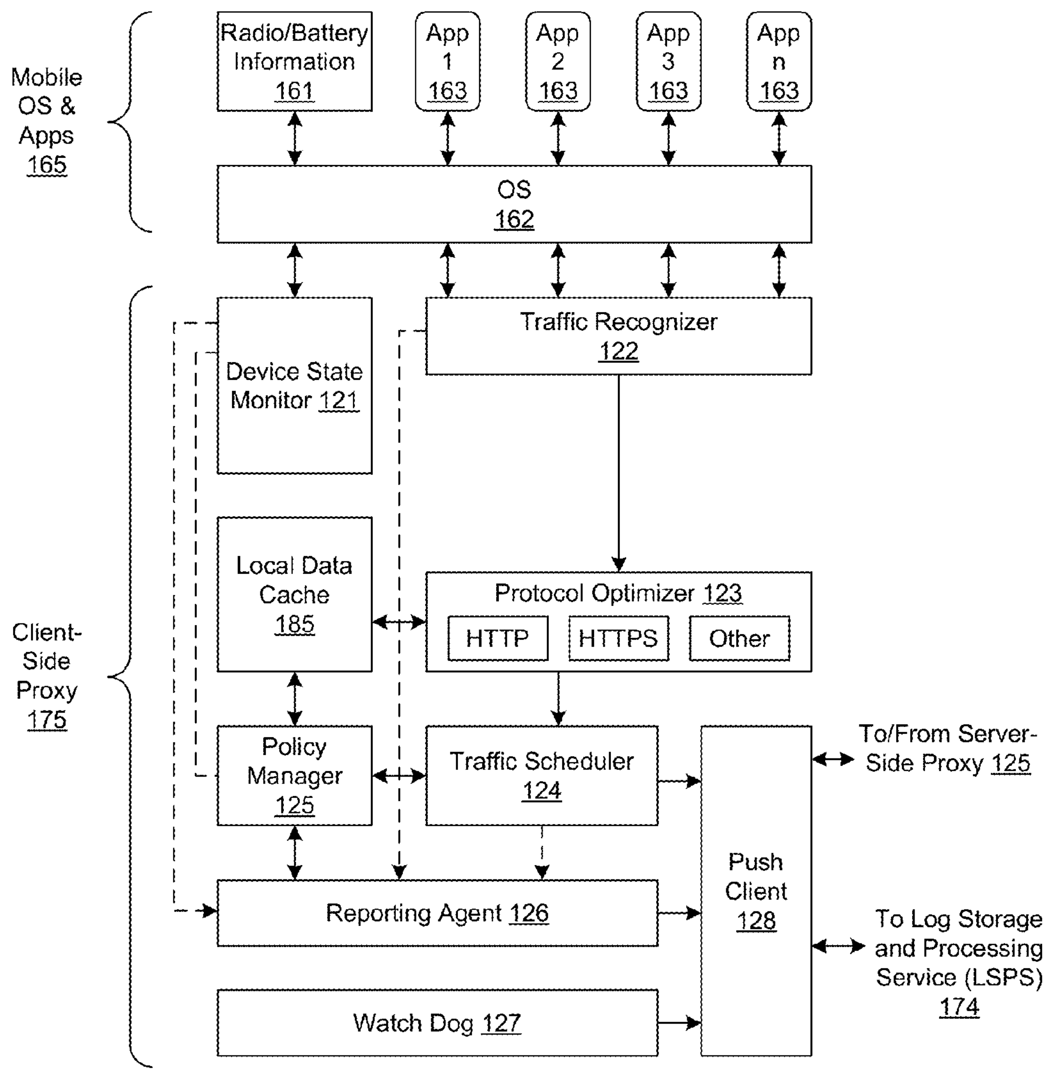

110
Third Party Server 1
D
C
125
Server Cache 116
Server-Side Proxy
S6
B
S5
A
114
Operator Network 152
112
Network-Side Proxy
Incoming Traffic Alignment/Blocking/ Shaping
S4
Radio 151
S3
150
175
Client-Side Proxy
Local Cache 185
Mobile Device
S2
S1
163
App
Outgoing Traffic Alignment/Blocking/ Shaping

FIG. 1E



Mobile OS & Apps 165
Radio/Battery Information 161
App 1 163
App 2 163
App 3 163
App n 163
OS 162
Client-Side Proxy 175
Device State Monitor 121
Traffic Recognizer 122
Local Data Cache 185
Protocol Optimizer 123
HTTP
HTTPS
Other
Policy Manager 125
Traffic Scheduler 124
Push Client 128
To/From Server-Side Proxy 125
Reporting Agent 126
To Log Storage and Processing Service (LSPS) 174
Watch Dog 127

FIG. 1F

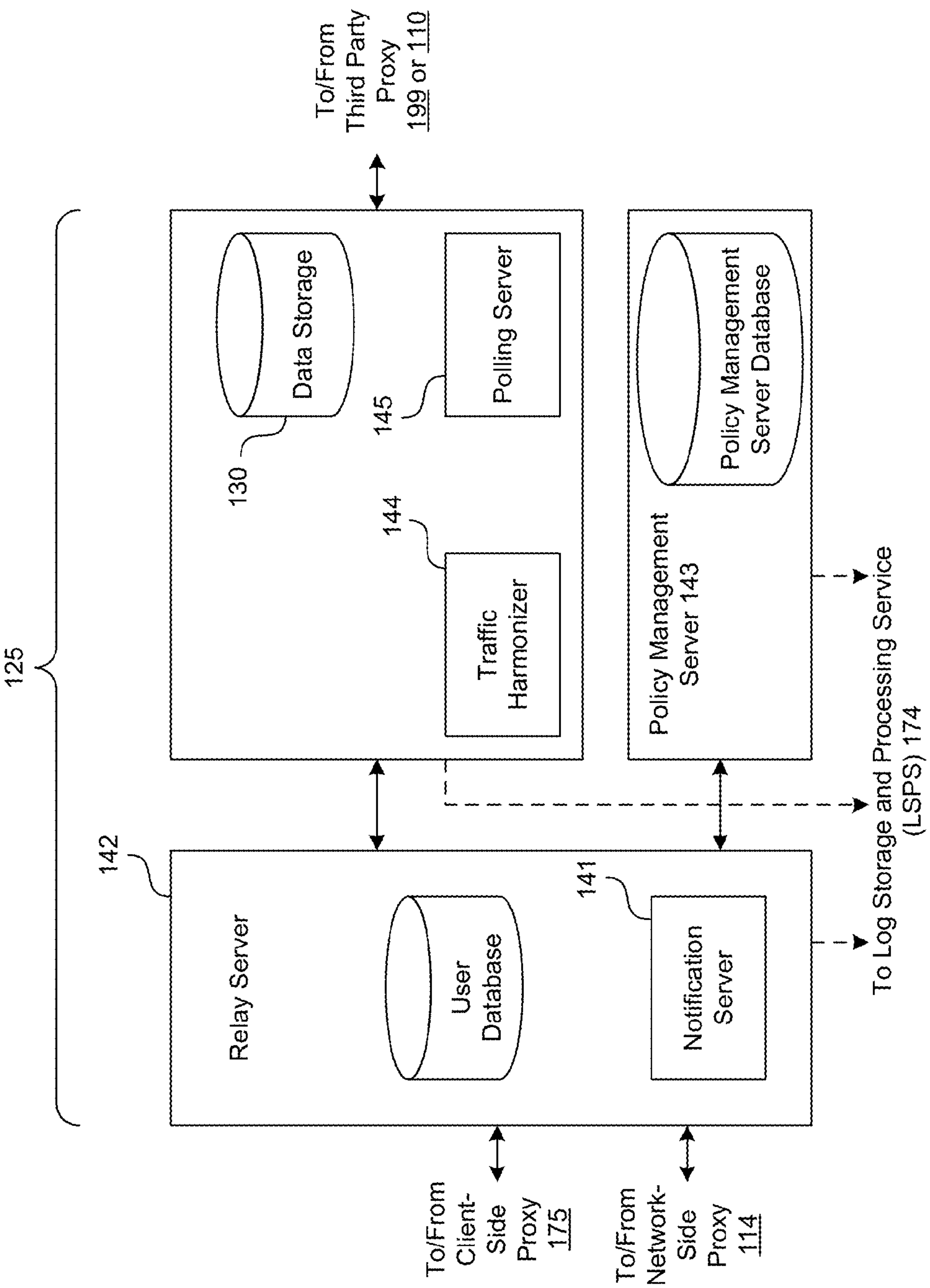
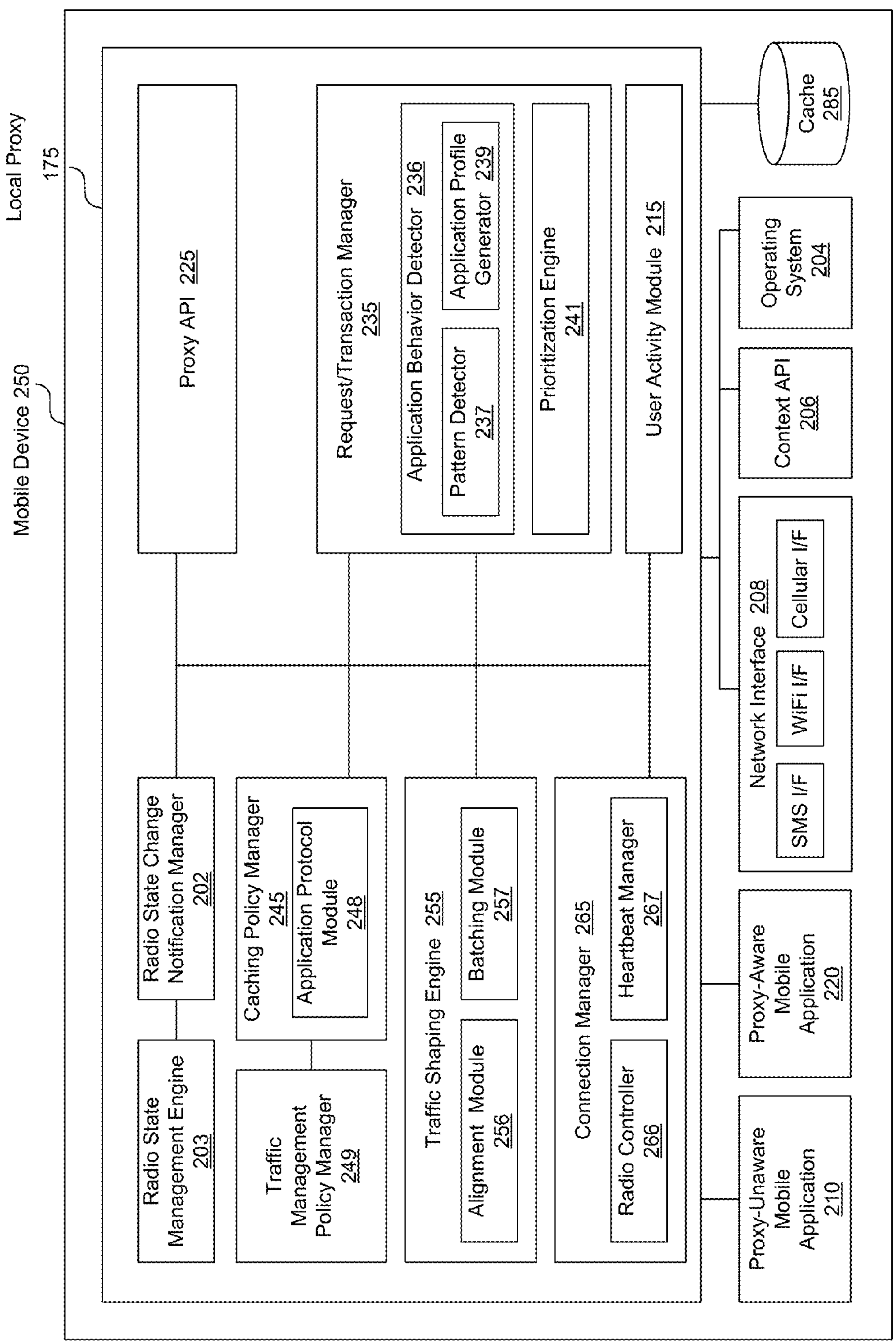

To/From Third Party Proxy 199 or 110
125
Data Storage
130
Polling Server
145
Traffic Harmonizer
144
Policy Management Server Database
Policy Management Server 143
142
Relay Server
User Database
141
Notification Server
To Log Storage and Processing Service (LSPS) 174
To/From Client-Side Proxy 175
To/From Network-Side Proxy 114

FIG. 1G



Mobile Device 250
Local Proxy 175
Proxy API 225
Request/Transaction Manager 235
Application Behavior Detector 236
Pattern Detector 237
Application Profile Generator 239
Prioritization Engine 241
User Activity Module 215
Cache 285
Operating System 204
Context API 206
Network Interface 208
Cellular I/F
WiFi I/F
SMS I/F
Radio State Change Notification Manager 202
Radio State Management Engine 203
Caching Policy Manager 245
Application Protocol Module 248
Traffic Management Policy Manager 249
Traffic Shaping Engine 255
Batching Module 257
Alignment Module 256
Connection Manager 265
Heartbeat Manager 267
Radio Controller 266
Proxy-Aware Mobile Application 220
Proxy-Unaware Mobile Application 210

FIG. 2A

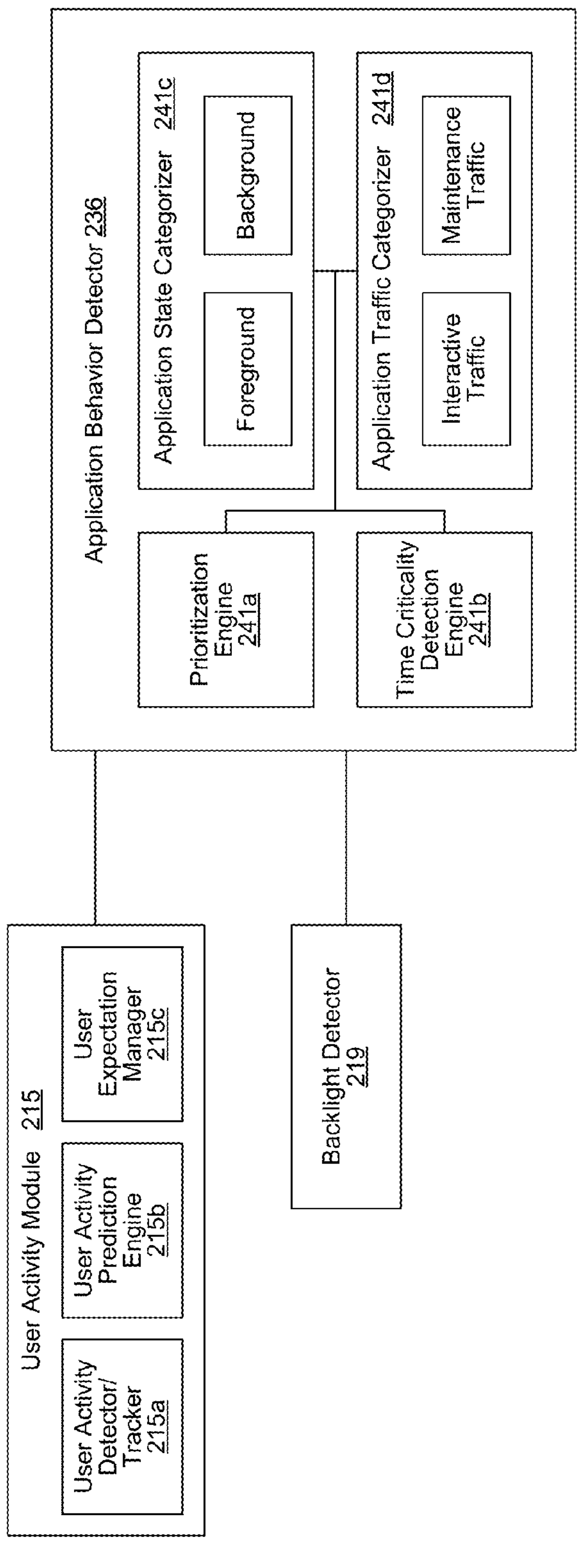
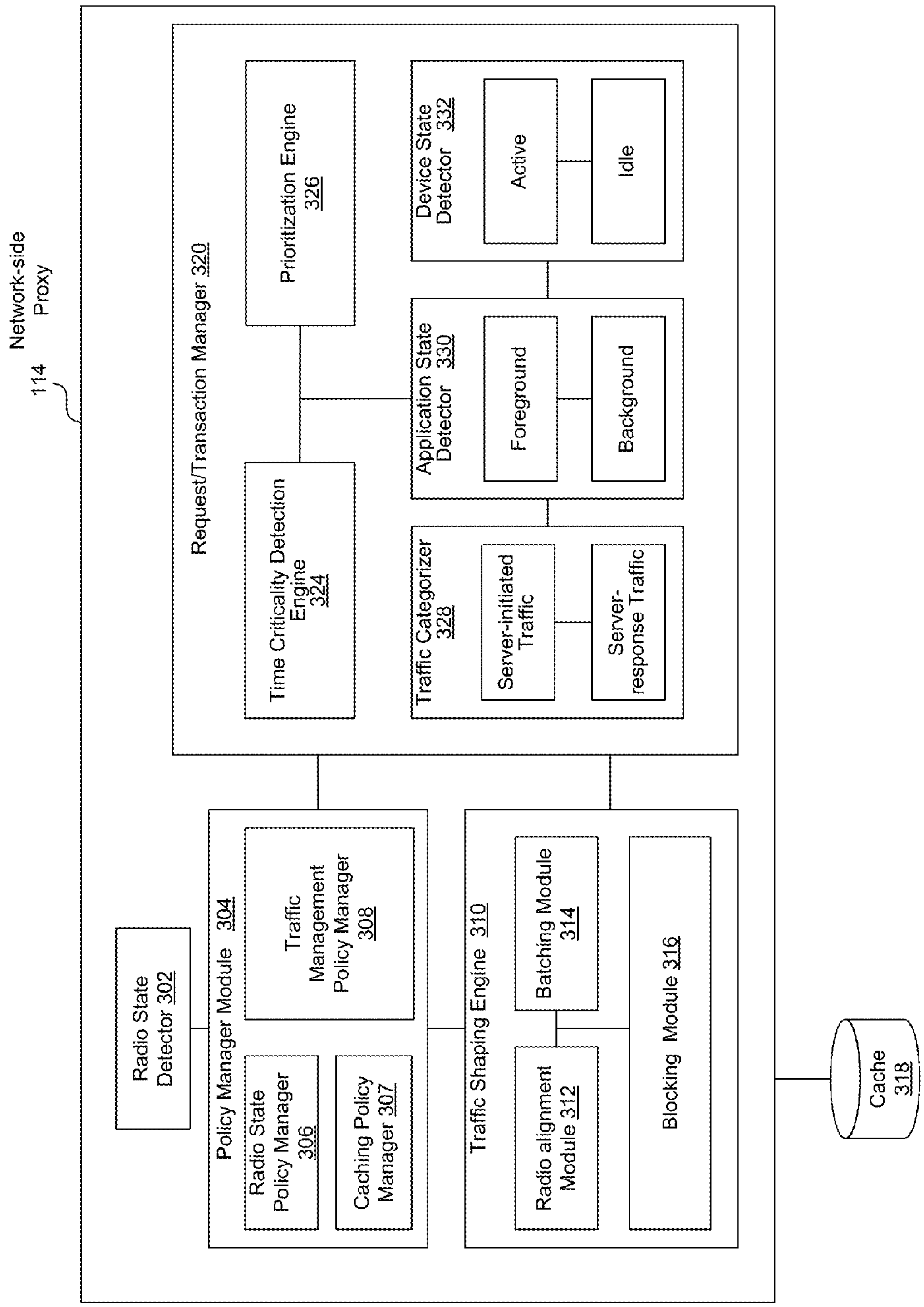

Application Behavior Detector 236
Application State Categorizer 241c
Foreground
Background
Application Traffic Categorizer 241d
Interactive Traffic
Maintenance Traffic
Prioritization Engine 241a
Time Criticality Detection Engine 241b
User Activity Module 215
User Activity Detector/ Tracker 215a
User Activity Prediction Engine 215b
User Expectation Manager 215c
Backlight Detector 219

FIG. 2B



114
Network-side Proxy
Request/Transaction Manager 320
Prioritization Engine 326
Time Criticality Detection Engine 324
Device State Detector 332
Active
Idle
Application State Detector 330
Foreground
Background
Traffic Categorizer 328
Server-initiated Traffic
Server-response Traffic
Radio State Detector 302
Policy Manager Module 304
Traffic Management Policy Manager 308
Radio State Policy Manager 306
Caching Policy Manager 307
Traffic Shaping Engine 310
Batching Module 314
Radio alignment Module 312
Blocking Module 316
Cache 318

FIG. 3

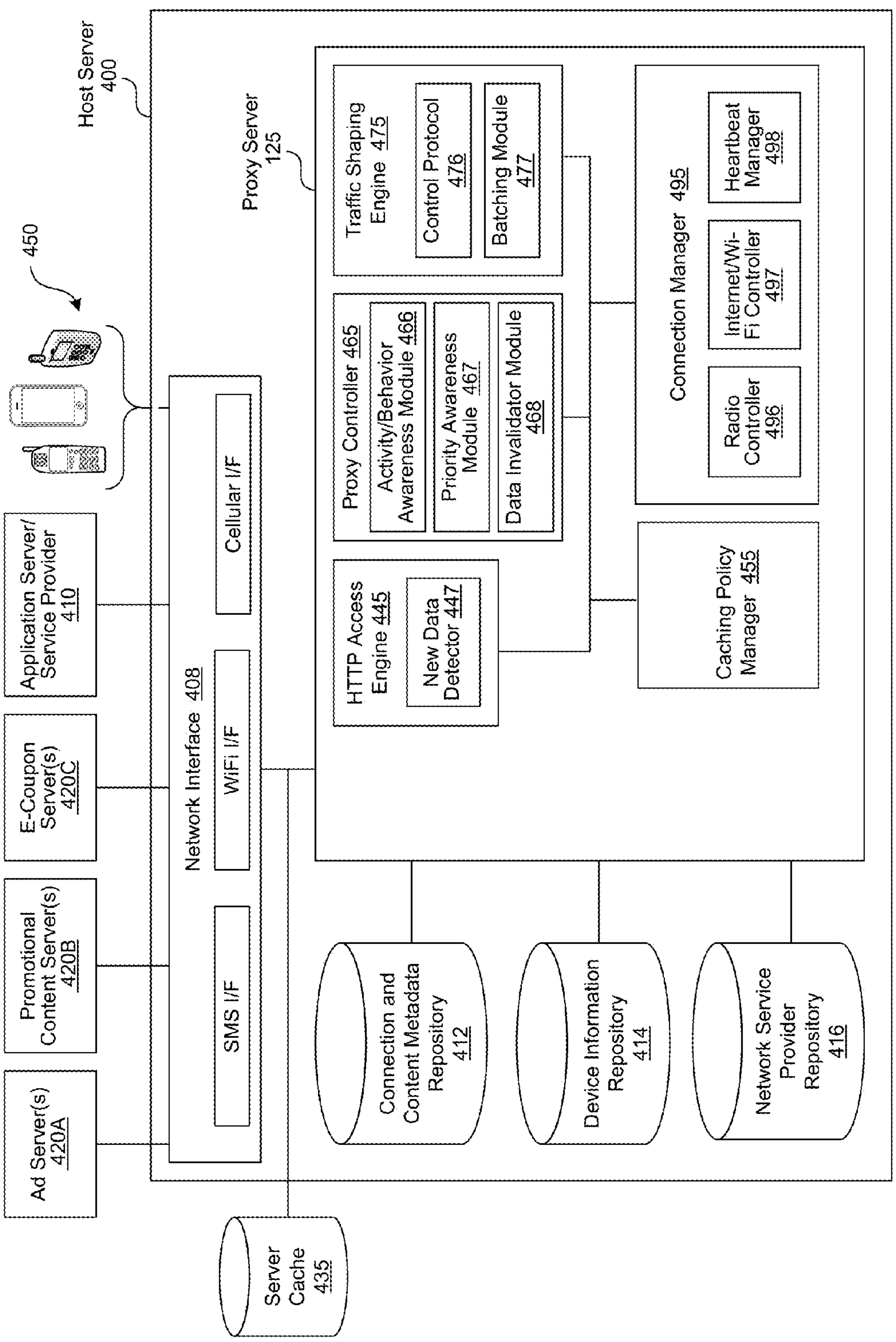

Host Server
400
Proxy Server
125
450
Traffic Shaping Engine 475
Control Protocol 476
Batching Module 477
Proxy Controller 465
Activity/Behavior Awareness Module 466
Priority Awareness Module 467
Data Invalidator Module 468
HTTP Access Engine 445
New Data Detector 447
Connection Manager 495
Radio Controller 496
Internet/Wi-Fi Controller 497
Heartbeat Manager 498
Caching Policy Manager 455
Network Interface 408
SMS I/F
WiFi I/F
Cellular I/F
Application Server/ Service Provider 410
E-Coupon Server(s) 420C
Promotional Content Server(s) 420B
Ad Server(s) 420A
Connection and Content Metadata Repository 412
Device Information Repository 414
Network Service Provider Repository 416
Server Cache 435

FIG. 4A

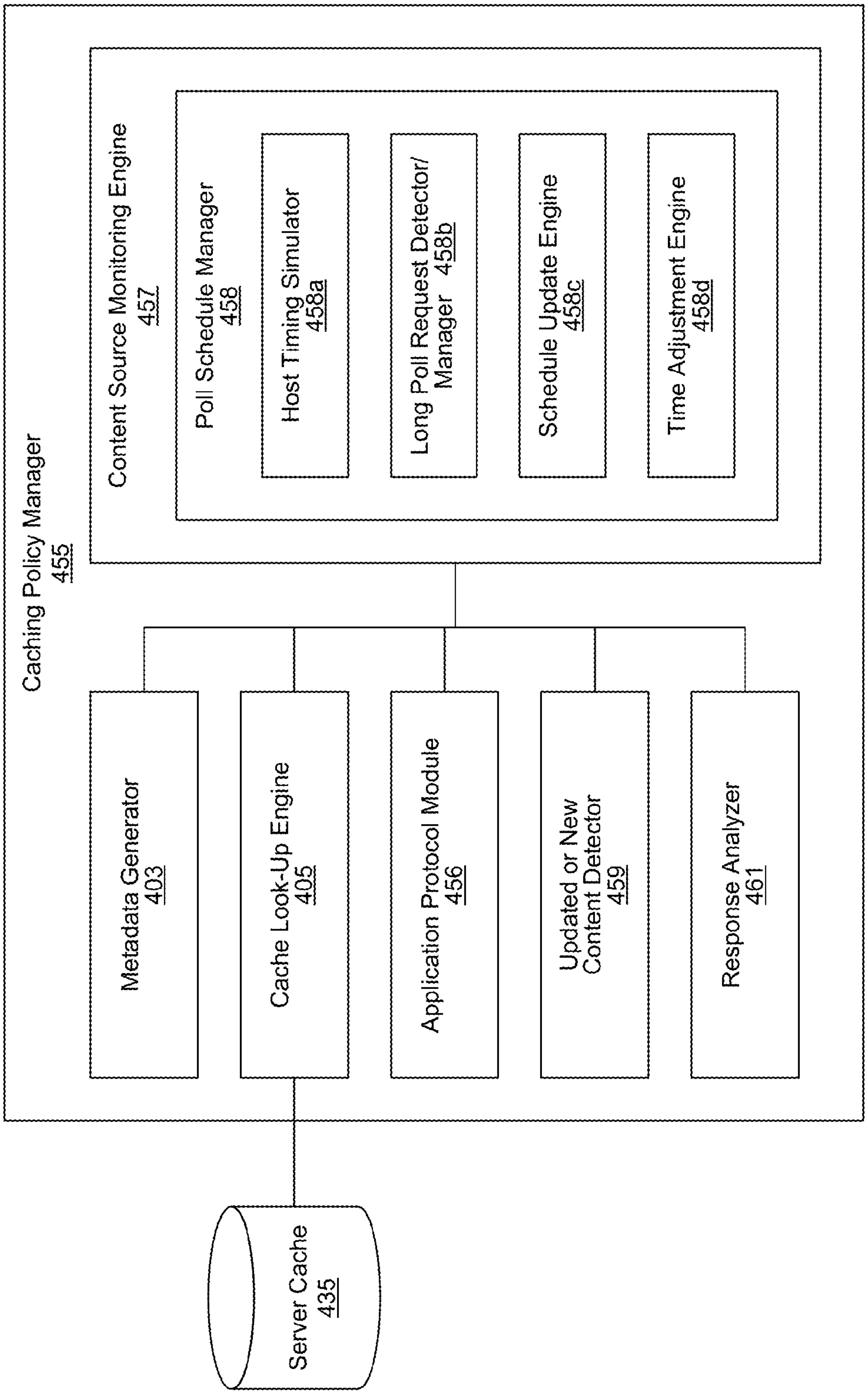
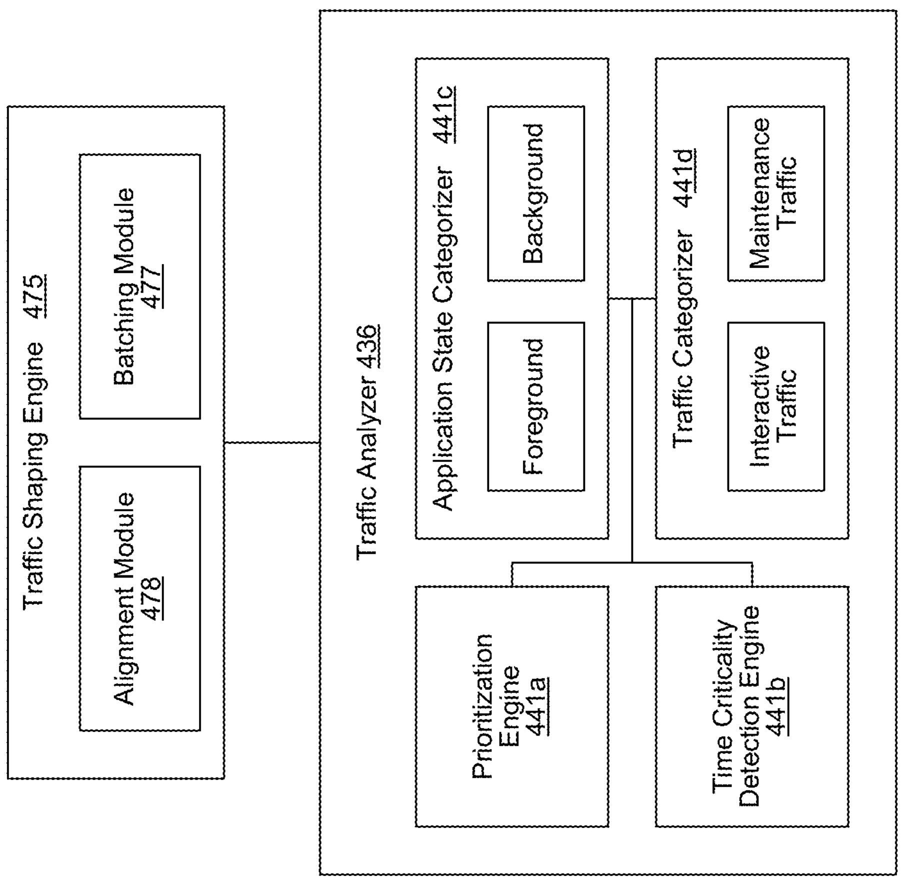

Caching Policy Manager
455
Content Source Monitoring Engine
457
Poll Schedule Manager
458
Host Timing Simulator
458a
Long Poll Request Detector/
Manager 458b
Schedule Update Engine
458c
Time Adjustment Engine
458d
Metadata Generator
403
Cache Look-Up Engine
405
Application Protocol Module
456
Updated or New
Content Detector
459
Response Analyzer
461
Server Cache
435

FIG. 4B



Traffic Shaping Engine 475
Batching Module 477
Alignment Module 478
Traffic Analyzer 436
Application State Categorizer 441c
Background
Foreground
Traffic Categorizer 441d
Maintenance Traffic
Interactive Traffic
Prioritization Engine 441a
Time Criticality Detection Engine 441b

FIG. 4C

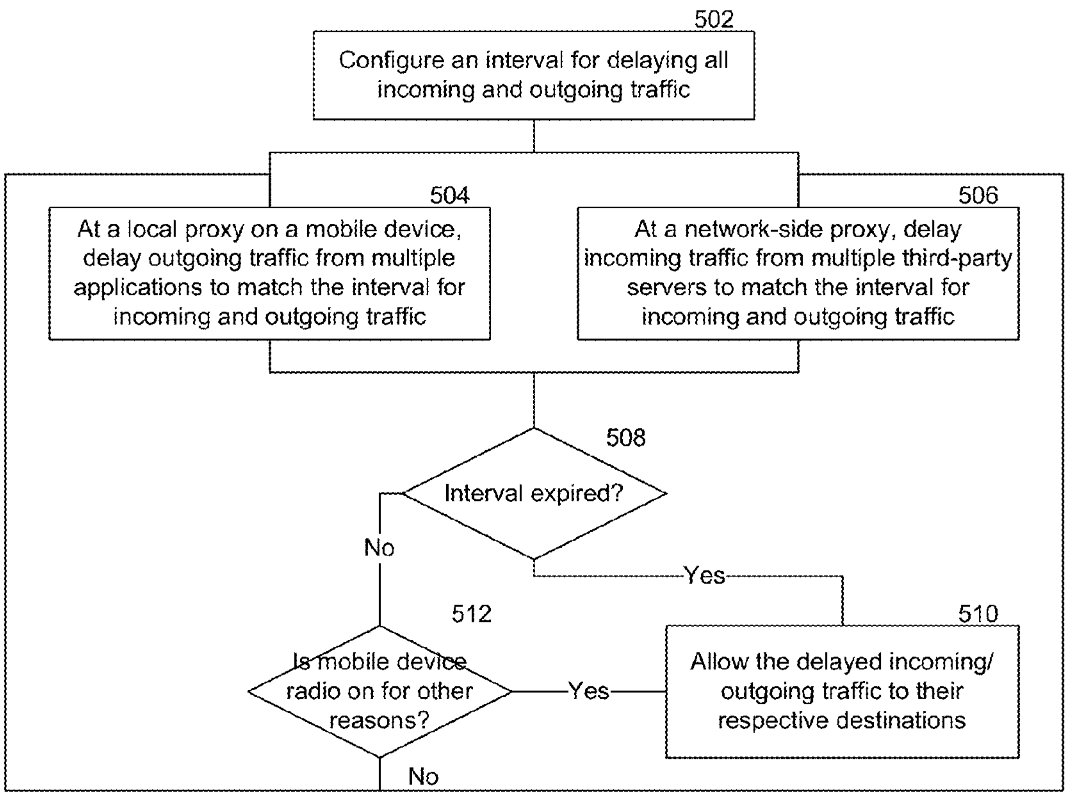

502
Configure an interval for delaying all incoming and outgoing traffic
504
At a local proxy on a mobile device, delay outgoing traffic from multiple applications to match the interval for incoming and outgoing traffic
506
At a network-side proxy, delay incoming traffic from multiple third-party servers to match the interval for incoming and outgoing traffic
508
Interval expired?
No
Yes
510
Allow the delayed incoming/ outgoing traffic to their respective destinations
512
Is mobile device radio on for other reasons?
Yes
No

FIG. 5A

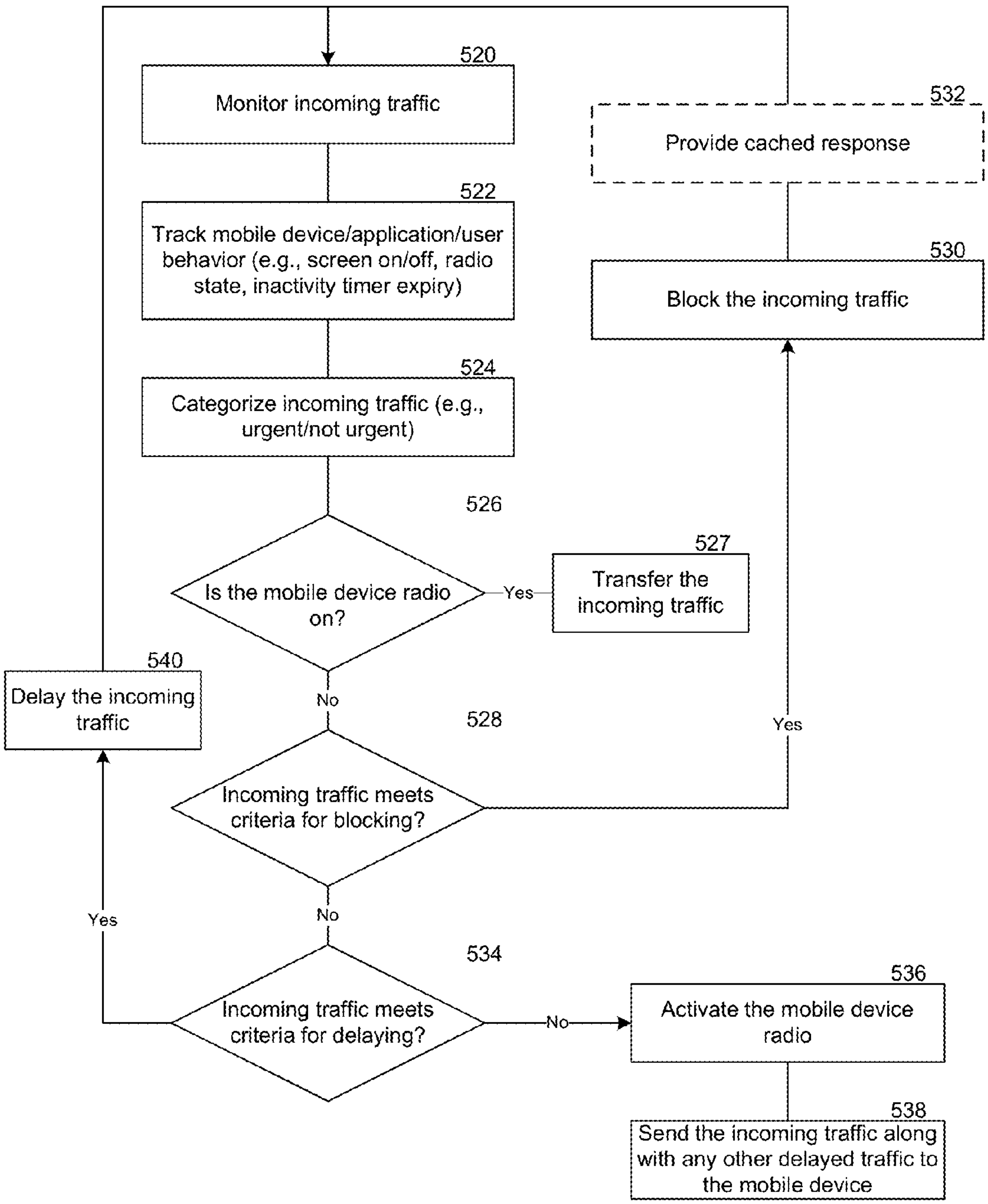

520
Monitor incoming traffic
522
Track mobile device/application/user behavior (e.g., screen on/off, radio state, inactivity timer expiry)
524
Categorize incoming traffic (e.g., urgent/not urgent)
526
Is the mobile device radio on?
Yes
527
Transfer the incoming traffic
No
528
Incoming traffic meets criteria for blocking?
Yes
530
Block the incoming traffic
532
Provide cached response
No
534
Incoming traffic meets criteria for delaying?
Yes
540
Delay the incoming traffic
No
536
Activate the mobile device radio
538
Send the incoming traffic along with any other delayed traffic to the mobile device

FIG. 5B

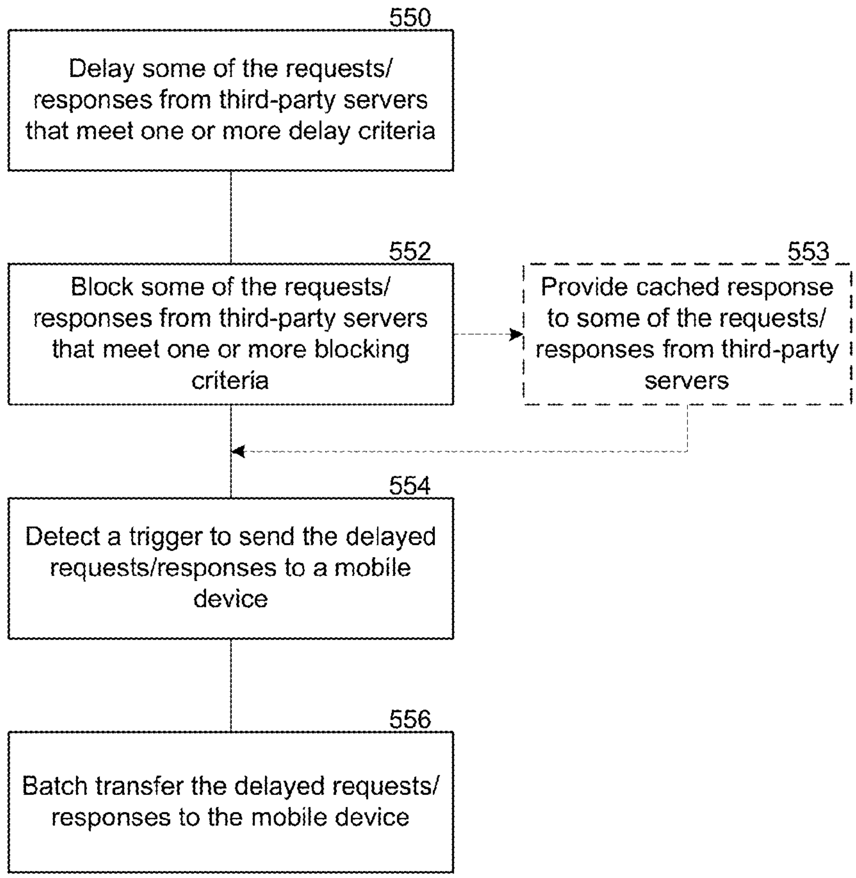

550
Delay some of the requests/ responses from third-party servers that meet one or more delay criteria
552
Block some of the requests/ responses from third-party servers that meet one or more blocking criteria
553
Provide cached response to some of the requests/ responses from third-party servers
554
Detect a trigger to send the delayed requests/responses to a mobile device
556
Batch transfer the delayed requests/ responses to the mobile device

FIG. 5C

Traffic Category/Application Category 600	
Interactive traffic	Background traffic
User waiting for response	User not waiting for response
Application in foreground	Application in background
Backlight on	Backlight off

FIG. 6

Content Category 700	
High priority	Low priority
Time critical	Non-time critical

FIG. 7

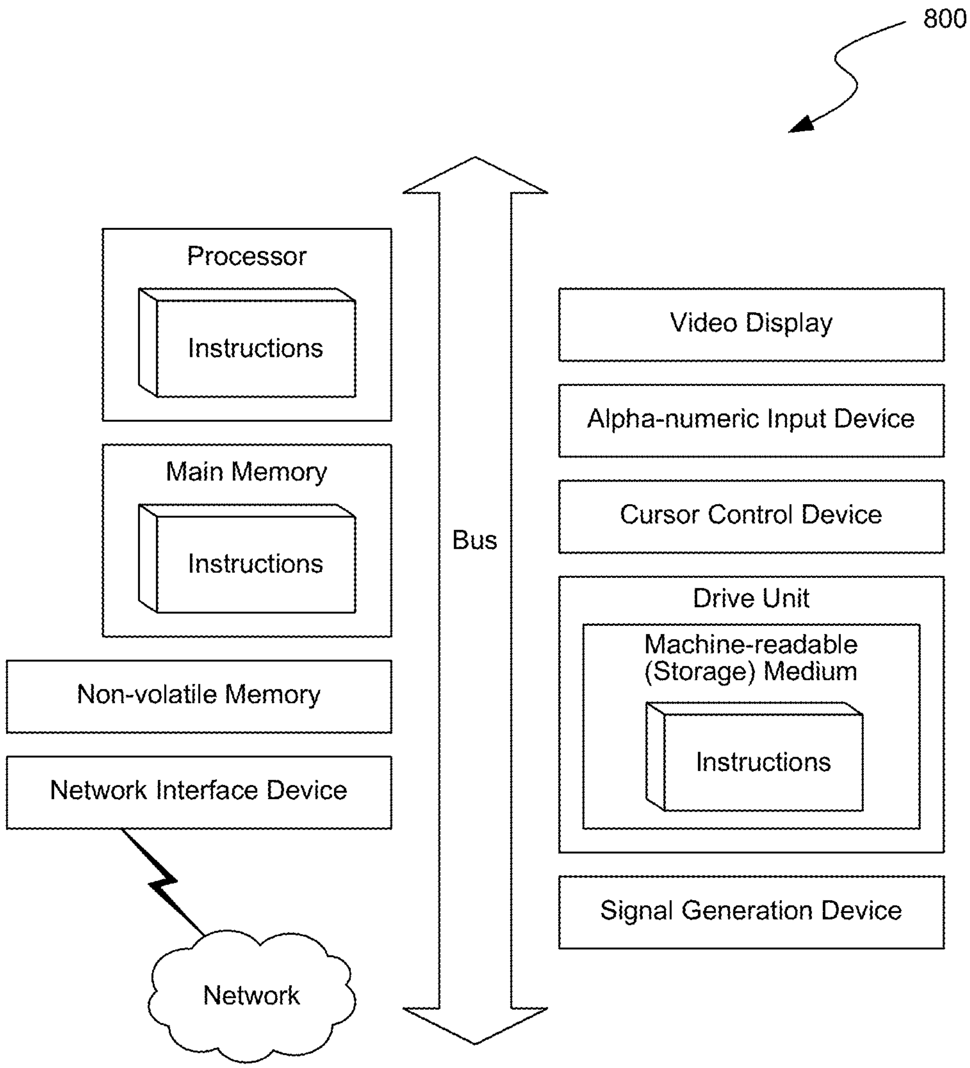

800
Processor
Instructions
Main Memory
Instructions
Non-volatile Memory
Network Interface Device
Network
Bus
Video Display
Alpha-numeric Input Device
Cursor Control Device
Drive Unit
Machine-readable
(Storage) Medium
Instructions
Signal Generation Device

FIG. 8

PROXY SERVER ASSOCIATED WITH A MOBILE CARRIER FOR ENHANCING MOBILE TRAFFIC MANAGEMENT IN A MOBILE NETWORK

CROSS-REFERENCE TO RELATED APPLICATION

The present application claims priority to and benefit from U.S. Provisional Patent Application Ser. No. 61/857,175 titled "a Proxy Server Associated with a Mobile Carrier for Enhancing Mobile Traffic Management in a Mobile Network", filed on Jul. 22, 2013, and is related to U.S. patent application Ser. No. 13/844,682 titled "Management of Mobile Device Radio State Promotion and Demotion", filed on Mar. 15, 2013 and U.S. patent application Ser. No. 14/147,434 titled "Modifying System Timers for Optimizing Mobile Traffic Management", filed on Jan. 3, 2014. The entire content of the aforementioned applications is hereby incorporated by reference in their entirety.

BACKGROUND

Servers such as application servers and content providers periodically use push technology to request or transfer information to applications on the mobile devices. These server pushes from various application servers can result in a large number of network connections, with only a small amount of data being sent per connection session. Such behavior in a mobile network loads the mobile network with the extra signaling, resulting in mobile network congestion and degradation of the performance of mobile data sessions. Furthermore, a radio on a mobile device typically prefers to remain in an idle state to preserve power. Each time a server pushes data to the mobile device, the radio on the mobile device has to transition from the idle state to a connected state, and back down to the idle state following completion of data transfer. The frequent radio state transitions associated with a large number of network connections drains battery life in the mobile devices.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A depicts an example timing diagram for aligning outgoing and incoming traffic by a distributed proxy and cache system for enhancing mobile traffic management and resource conservation in a mobile network.

FIG. **1**B illustrates an example diagram of a system where a host server facilitates management of traffic, content caching, and/or resource conservation between mobile devices (e.g., wireless devices), an application server or content provider, or other servers such as an ad server, promotional content server, or an e-coupon server in a wireless network (or broadband network) for a distributed proxy system for enhancing mobile traffic management and resource conservation in the mobile network.

FIG. **1**C illustrates an example diagram of a proxy and cache system distributed between the host server, operator network and a mobile device which facilitates network traffic management between the mobile device, an application server or content provider, or other servers such as an ad server, promotional content server, or an e-coupon server for traffic management, resource conservation and content caching. The network-side proxy in the operator network can further enhance mobile traffic management and resource conservation in a mobile network.

FIG. **1**D illustrates an example diagram of the logical architecture of a distributed proxy and cache system, including a client-side proxy, a server-side proxy, a network-side proxy and a log storage and processing service.

FIG. **1**E illustrates an example diagram of the logical architecture of a distributed proxy and cache system comprising six sockets distributed over a client-side proxy, a network-side proxy and a third-party server to enhance mobile traffic management and resource conservation in a mobile network.

FIG. **1**F illustrates an example diagram showing the architecture of client side components in a distributed proxy and cache system.

FIG. **1**G illustrates a diagram of example components on a server side of a distributed proxy and cache system.

FIG. **2**A illustrates a block diagram depicting an example of client-side components in a distributed proxy and cache system, including components for managing outgoing traffic from multiple applications on a mobile device to enhance mobile traffic management and resource conservation in a mobile network.

FIG. **2**B illustrates a block diagram depicting additional components in a user activity module and an application behavior detector, shown in the example of FIG. **2**A.

FIG. **3** illustrates a block diagram depicting an example of network-side components in a distributed proxy and cache system, including components for managing incoming traffic from third-party servers to enhance mobile traffic management and resource conservation in a mobile network.

FIG. **4**A depicts a block diagram illustrating an example of server-side components, in certain embodiments of a distributed proxy and cache system that manage traffic in a wireless network (or broadband network) for resource conservation, content caching, and/or traffic management. In some embodiments, the server-side proxy (or proxy server) can further categorize mobile traffic and/or deploy and/or implement policies such as traffic management and delivery policies based on device state, application behavior, content priority, user activity, and/or user expectations.

FIG. **4**B depicts a block diagram illustrating a further example of components in a caching policy manager in the distributed proxy and cache system shown in the example of FIG. **4**A which is capable of caching and adapting caching strategies for mobile application behavior and/or network conditions. Components capable in some embodiments of detecting long poll requests and managing caching of long polls are also illustrated.

FIG. **4**C depicts a block diagram illustrating examples of additional components in certain embodiments in a proxy server shown in the example of FIG. **4**A, which is further capable of performing mobile traffic categorization and policy implementation based on application behavior and/or traffic priority to enhance mobile traffic management and resource conservation in a mobile network.

FIGS. **5**A-C illustrate logic flow diagrams of example methods for enhancing mobile traffic management and resource conservation in a mobile network.

FIG. **6** illustrates a table showing examples of different traffic or application category types which can be used for enhancing mobile traffic management.

FIG. **7** depicts a table showing examples of different content category types which can be used enhancing mobile traffic management.

FIG. **8** shows a diagrammatic representation of a machine in the example form of a computer system within which a set of instructions, for causing the machine to perform any one or more of the methodologies discussed herein, may be executed.

DETAILED DESCRIPTION

The following description and drawings are illustrative and are not to be construed as limiting. Numerous specific details are described to provide a thorough understanding of the disclosure. However, in certain instances, well-known or conventional details are not described in order to avoid obscuring the description. References to one or an embodiment in the present disclosure can be, but are not necessarily, references to the same embodiment, and such references mean at least one of the embodiments.

Reference in this specification to “one embodiment” or “an embodiment” means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the disclosure. The appearances of the phrase “in one embodiment” in various places in the specification are not necessarily all referring to the same embodiment, nor are separate or alternative embodiments mutually exclusive of other embodiments. Moreover, various features are described which may be exhibited by some embodiments and not by others. Similarly, various requirements are described which may be requirements for some embodiments but not other embodiments.

The terms used in this specification generally have their ordinary meanings in the art, within the context of the disclosure, and in the specific context where each term is used. Certain terms that are used to describe the disclosure are discussed below, or elsewhere in the specification, to provide additional guidance to the practitioner regarding the description of the disclosure. For convenience, certain terms may be highlighted, for example using italics and/or quotation marks. The use of highlighting has no influence on the scope and meaning of a term; the scope and meaning of a term is the same, in the same context, whether or not it is highlighted. It will be appreciated that the same thing can be said in more than one way.

Consequently, alternative language and synonyms may be used for any one or more of the terms discussed herein, nor is any special significance to be placed upon whether or not a term is elaborated or discussed herein. Synonyms for certain terms are provided. A recital of one or more synonyms does not exclude the use of other synonyms. The use of examples anywhere in this specification including examples of any terms discussed herein is illustrative only, and is not intended to further limit the scope and meaning of the disclosure or of any exemplified term. Likewise, the disclosure is not limited to various embodiments given in this specification.

As used herein, a “module,” “a manager,” a “handler,” a “detector,” an “interface,” a “controller,” a “normalizer,” a “generator,” an “invalidator,” a “categorizer” or an “engine” includes a general purpose, dedicated or shared processor and, typically, firmware or software modules that are executed by the processor. Depending upon implementation-specific or other considerations, the module, manager, handler, detector, interface, controller, normalizer, generator, invalidator, categorizer or engine can be centralized or its functionality distributed. The module, manager, handler, detector, interface, controller, normalizer, generator, invalidator, or engine can include general or special purpose hardware, firmware, or software embodied in a computer-readable (storage) medium for execution by the processor.

As used herein, a computer-readable medium or computer-readable storage medium is intended to include all mediums that are statutory (e.g., in the United States, under 35 U.S.C. 101), and to specifically exclude all mediums that are non-statutory in nature to the extent that the exclusion is necessary for a claim that includes the computer-readable (storage) medium to be valid. Known statutory computer-readable mediums include hardware (e.g., registers, random access memory (RAM), non-volatile (NV) storage, to name a few), but may or may not be limited to hardware.

Without intent to limit the scope of the disclosure, examples of instruments, apparatus, methods and their related results according to the embodiments of the present disclosure, are given below. Note that titles or subtitles may be used in the examples for convenience of a reader, which in no way should limit the scope of the disclosure. Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure pertains. In the case of conflict, the present document, including definitions, will control.

Mobile Traffic Management

Many applications receive notifications or requests initiated by application servers (“push mechanism”). The application servers or push servers then periodically push new/updated data to mobile devices. Embodiments of the present disclosure include a proxy server associated with or residing on a mobile carrier or a mobile operator network for managing incoming traffic initiated by application servers for enhancing mobile traffic management in a mobile network. As used herein, incoming traffic includes traffic initiated by one or more application servers associated with one or more mobile applications on a mobile device. By way of example, incoming traffic can include VIBER, WHATSAPP, LINE and other application messages initiated from the server side, i.e., from the application servers.

As used herein, a network-side proxy is a proxy server associated with or residing on a mobile carrier or a mobile operator network. In some embodiments, the network-side proxy may reside in a mobile operator or carrier’s core network or the radio access network. In other embodiments, the network-side proxy may be coupled to or be a component of a mobile operator server or other infrastructure. The network-side proxy can be aware of the radio state of the mobile devices to radio-align incoming traffic to optimize network initiated radio connections and thereby enhance mobile traffic management and resource conservation in a mobile network. In some other embodiments, the network-side proxy manages server responses (e.g., responses to requests initiated from mobile devices and thus different from incoming traffic) from application servers that are delayed beyond the radio dormancy timeouts to optimize the number of radio connections caused by such delayed responses. For example, in some operator settings, the inactivity timer or radio dormancy timeout is as short as 3 seconds. If an HTTP response from an application server comes back in 4 seconds, after the radio on the mobile device is demoted to an idle state, the HTTP response can cause the radio to be promoted back to a connected or active state. The network-side proxy can intercept and accumulate such response traffic from application servers and transfer them when the radio on the mobile device is active. The interception can be selective, so that response traffic which is critical or high priority can cause immediate radio promotion on the mobile device. In yet other embodiments, the network-side proxy manages incoming traffic initiated by application servers, such as messages from VIBER, WHATSAPP, LINE, and the like, using one or more alignment techniques. Example techniques for aligning requests include, but are not limited to, delaying, clumping (also referred to as gating or bundling), blocking or restricting, prioritizing, filtering and the like.

Many applications initiate application requests from the mobile device side to request updates (“pull mechanism”).

Embodiments of the present disclosure include a local proxy on a mobile device that provides a client-side traffic management solution for managing application requests initiated from the mobile device. The local proxy can, for example, batch or align outgoing traffic originating from one or more applications so that fewer connection attempts are made from the client side, resulting in fewer radio state transitions (e.g., transition from idle to connected state or vice versa, transition from low power to high power state or vice versa) and thereby enhancing mobile traffic management and resource conservation in a mobile network. As used herein, outgoing traffic includes traffic initiated from a mobile device. By way of example, outgoing traffic can include requests (user initiated or background requests) from mobile applications on a mobile device, transport or transmission protocol messages (e.g., SYN, ACK, FIN, RST), and the like.

Embodiments of the present disclosure also include a distributed proxy and cache system including a network-side proxy associated with a mobile operator, a local proxy on a mobile device and/or a proxy server associated with a host server and methods for enhancing management of incoming and outgoing traffic to reduce signaling and conserve resources in a mobile network. With the client-side traffic management solution for pull requests and the network-side (i.e., at the network-side proxy) traffic management solution for push requests, the disclosed technology provides an intelligent traffic management solution for reducing signaling in the mobile network and conserving battery and network resources.

In some embodiments of the distributed proxy and cache system, the network-side proxy and the local proxy agree on an interval, and delay incoming traffic (at the network-side proxy) and outgoing traffic (at the local proxy) to match that interval. In other embodiments of the distributed proxy and cache system, the local proxy, via a one way radio-aware control channel between the local proxy and the network-side proxy, provides information concerning the mobile device, applications, and/or user behavior or activity that can be utilized by the network-side proxy to align, delay, clump, block or otherwise manage incoming traffic to optimize radio connections initiated from activities of application servers and thereby enhance mobile traffic management and resource conservation in a mobile network. In yet other embodiments of the distributed proxy and cache system, the network-side proxy uses caching strategy to provide cached responses to third-party server requests to further optimize network initiated radio connections and thereby enhance mobile traffic management and resource conservation in a mobile network. In some embodiments of the distributed proxy and cache system including a network-side proxy, a local proxy and/or a server-side proxy, incoming and outgoing traffic can be managed based on traffic management policies to optimize radio connections initiated from activities of application servers and thereby enhance mobile traffic management and resource conservation in a mobile network.

Certain embodiments of the disclosed technology includes, for example, alignment of requests from multiple applications to minimize the need for several polling requests, leverage specific content types to determine how to proxy/manage a connection/content, and application of specific heuristics associated with device, user behavioral patterns (how often they interact with the device/application) and/or network parameters to intelligently manage traffic at the device level.

Certain disclosed embodiments can further include, moving recurring Hypertext Transfer Protocol (HTTP) polls performed by various widgets, RSS readers, etc., to remote network node (e.g., Network Operation Center (NOC)), thus considerably lowering device battery/power consumption, radio channel signaling and bandwidth usage. Additionally, the offloading can be performed transparently so that existing applications do not need to be changed.

In some embodiments, this can be implemented using a local proxy on the mobile device (e.g., any wireless device) which automatically detects recurring requests for the same content (RSS feed, Widget data set) that matches a specific rule (e.g., happens every 15 minutes). The local proxy can automatically cache the content on the mobile device while delegating the polling to the server (e.g., a proxy server operated as an element of a communications network). The server can then notify the mobile/client proxy if the content changes, and if content has not changed (or not changed sufficiently, or in an identified manner or amount) the mobile proxy provides the latest version in its cache to the user (without need to utilize the radio at all). This way the mobile or wireless device (e.g., a mobile phone, smart phone, M2M module/MODEM, or any other wireless devices, etc.) does not need to open (e.g., thus powering on the radio) or use a data connection if the request is for content that is monitored and that has been not flagged as new/changed.

The logic for automatically adding content sources/application servers (e.g., including URLs/content) to be monitored can also check for various factors like how often the content is the same, how often the same request is made (is there a fixed interval/pattern?), which application is requesting the data, etc. Similar rules to decide between using the cache and request the data from the original source may also be implemented and executed by the local proxy and/or server in certain embodiments.

For example, when the request comes at an unscheduled/unexpected time (user initiated check), or after every (n) consecutive times the response has been provided from the cache, etc., or if the application is running in the background vs. in a more interactive mode of the foreground. As more and more mobile applications or wireless enabled applications base their features on resources available in the network, this becomes increasingly important. In addition, the disclosed technology allows elimination of unnecessary chatter from the network, benefiting the operators trying to optimize the wireless spectrum usage.

Traffic Categorization and Policy

In some embodiments, the disclosed proxy system is able to establish policies for choosing traffic (data, content, messages, updates, etc.) to cache and/or shape. Additionally, by combining information from observing the application making the network requests, getting explicit information from the application, or knowing the network destination the application is reaching, the disclosed technology can determine or infer what category the transmitted traffic belongs to.

For example, in some embodiments, mobile or wireless traffic can be categorized as: (a1) interactive traffic or (a2) background traffic. The difference is that in (a1) a user is actively waiting for a response, while in (a2) a user is not expecting a response. This categorization can be used in conjunction with or in lieu of a second type of categorization of traffic: (b1) immediate, (b2) low priority, (b3) immediate if the requesting application is in the foreground and active.

For example, a new update, message or email may be in the (b1) category to be delivered immediately, but it still is (a2) background traffic—a user is not actively waiting for it. A similar categorization applies to instant messages when they come outside of an active chat session. During an active chat session a user is expecting a response faster. Such user expectations are determined or inferred and factored into when optimizing network use and device resources in performing traffic categorization and policy implementation.

Some examples of the applications of the described categorization scheme include the following: (a1) interactive traffic can be categorized as (b1) immediate—but (a2) background traffic may also be (b2) or (b3). An example of a low priority transfer is email or message maintenance transaction such as deleting email or other messages or marking email as read at the mail or application server. Such a transfer can typically occur at the earlier of (a) timer exceeding a timeout value (for example, 2 minutes), and (b) data being sent for other purposes.

Examples example of (b3) are IM presence updates, stock ticker updates, weather updates, status updates and news feeds. When the UI of the application is in the foreground and/or active (for example, as indicated by the backlight of the device/phone being lit or as determined or inferred from the status of other sensors), updates can be considered immediate whenever the server has something to push to the device. When the application is not in the foreground or not active, such updates can be suppressed until the application comes to foreground and is active.

With some embodiments, networks can be selected or optimized simultaneously for (a1) interactive traffic and (a2) background traffic.

In some embodiments, as the wireless device or mobile device proxy (separately or in conjunction with the server proxy and/or the network-side proxy) is able to categorize the traffic as (for example) (a1) interactive traffic or (a2) background traffic, it can apply different policies to different types of traffic. This means that it can internally operate differently for (a1) and (a2) traffic (for example, by allowing interactive traffic to go through to the network or the mobile device in whole or in part, and apply stricter traffic control to background traffic or the device side only allows a request to activate the radio if it has received information from the server that the content at the host has been updated, etc.).

When the request does require access over the wireless network, the disclosed technology can request the radio layer to apply different network configurations to different traffic. Depending on the type of traffic and network, this may be achieved by different means:

(1) Using 3G/4G for (a1) and 2G/2.5G for (a2);
(2) Explicitly specifying network configuration for different data rates (e.g. in terms of use of FACH (forward access channel) vs. DCH (dedicated channel), or otherwise requesting lower/more network efficient data rates for background traffic); or
(3) Utilizing different network access points for different data rates (access points which would be configured to use network resources differently similar to (1) and (2) above).

Additionally, 3GPP Fast Dormancy calls for improvements so that applications, operating systems or the mobile device would have awareness of the traffic type to be more efficient in the future. Certain embodiments of the disclosed system, having the knowledge of the traffic category and being able to utilize Fast Dormancy appropriately may solve the problem identified in Fast Dormancy. In this manner, the mobile or broadband network does not need to be configured with a compromised configuration that adversely impacts both battery consumption and network signaling resources.

Polling Schedule

Detecting (or determining) a polling schedule allows the proxy server (server-side of the distributed cache system) to be as close as possible with its polls to the application polls. Many applications employ scheduled interval polling (e.g., every 4 hours or every 30 seconds, at another time interval). The client side proxy can detect automatic polls based on time measurements and create an automatic polling profile for an application. As an example, the local proxy attempts to detect the time interval between requests and after 2, 3, 4, or more polls, determines an automatic rate if the time intervals are all within 1 second (or another measure of relative closeness) of each other. If not, the client may collect data from a greater number of polling events (e.g., 10-12 polls) and apply a statistical analysis to determine, compute, or estimate a value for the average interval that is used. The polling profile is delivered to the server where it is used. If it is a frequent manual request, the locally proxy can substitute it with a default interval for this application taken from a profile for non-critical applications.

In some embodiments, the local proxy (e.g., device side proxy) may keep monitoring the application/client polls and update the polling interval. If it changes by more than 30% (or another predetermined/dynamic/conditional value) from the current value, it is communicated to the proxy server (e.g., server-side proxy). This approach can be referred to as the scenario of "lost interest." In some instances, the local proxy can recognize requests made outside of this schedule, consider them "manual," and treat them accordingly.

Application Classes/Modes of Caching

In some embodiments, applications can be organized into three groups or modes of caching. Each mobile client/application can be categorized to be treated as one of these modes, or treated using multiple modes, depending on one or more conditions.

A) Fully cached—local proxy updates (e.g., sends application requests directly over the network to be serviced by the application server/content host) only when the proxy server tells the local proxy to update. In this mode, the local proxy can ignore manual requests and the proxy server uses the detected automatic profile (e.g., sports score applets, Facebook, every 10, 15, 30, or more polls) to poll the application server/content provider.
B) Partially cached—the local proxy uses the local or internal cache for automatic requests (e.g., application automatic refreshes), other scheduled requests but passes through some manual requests (e.g., email download, EBay or some Facebook requests); and
C) Never cached (e.g., real-time stock ticker, sports scores/statuses; however, in some instances, 15 minutes delayed quotes can be safely placed on 30 seconds schedules—B or even A).

The actual application or caching mode classification can be determined based on the rate of content change and critical character of data. Unclassified applications by default can be set as class C.

Backlight and Active Applications

In some embodiments, the local proxy detects the device backlight status. Requests made with the screen light 'off' can be allowed to use the local cache if a request with identical signature is registered with the proxy server, which is polling the original host server/content server(s) to which the requests are directed. If the screen light is 'on', further detection can be made to determine whether it is a background application or for other indicators that local cache entries can or cannot be used to satisfy the request. When identified, the requests for which local entries can be used may be processed identically to the screen light off situation. Foreground requests can use the aforementioned application classification to assess when cached data is safe to use to process requests. In some embodiments, backlight and active application status information relating to a mobile device can be passed on to a network-side proxy to allow the network-side proxy to utilize such information in managing traffic directed towards the mobile device. For example, along with outgoing traffic, the local proxy can include an indication relating to screen on/off status, presence or absence of user activity, an indication of application which is currently being used by a user, and the like. Based on such information, the network-side proxy can adjust its alignment strategy. For example, if the screen is off, the network-side proxy can increase the interval for delaying incoming traffic.

FIG. **1**A depicts an example timing diagram for aligning outgoing and incoming traffic by a distributed proxy and cache system for enhancing mobile traffic management and resource conservation in a mobile network.

In the embodiment illustrated, a local proxy (e.g. local proxy **175** in FIGS. **1**C-**1**E and FIG. **2**A) on a mobile device (e.g., mobile device **150** in FIG. **1**C) and a network-side proxy (e.g., network-side proxy **114** in FIGS. **1**C-**1**E and FIG. **3**) in, of or otherwise associated with an operator network (e.g., the core network or the radio access network) agree on or determine an interval (e.g., time period T**1**) during which incoming and outgoing traffic are allowed to or from the mobile device. During the rest of the time (e.g., time period T**2**, T**3** and T**4**), any incoming traffic **119***a* are intercepted and accumulated at the network-side proxy and any outgoing traffic **118***a* are intercepted and accumulated at the local proxy. In some embodiments, the outgoing traffic includes background traffic, such as application requests initiated while the mobile device is in the background mode (i.e., mobile device is not being actively used by the user), requests associated with native applications, operating system operations, and the like. Many applications (e.g., mobile applications) such as social networking applications, news applications, weather applications, chat applications, gaming applications, and the like periodically initiate data sessions on their own, even when the mobile device is not being actively used by the user or even in the foreground. The requests from such data sessions are examples of background requests.

Some incoming traffic can include traffic initiated on the server-side by third party servers (e.g., application servers/content providers **110**, ad server(s) **120***a*, promotional content server(s) **120***b* and e-coupon servers **120***c* in FIG. **1**B and FIG. **1**C). Note that a third-party server and an application server is used interchangeably throughout the disclosure. Examples of incoming traffic can include VIBER, WHATSAPP, LINE, and other push-type application messages pushed to the mobile device. In some implementations, the incoming traffic excludes traffic such as HTTP responses to HTTP requests from the device-side, which are not server-initiated traffic but nevertheless can cause radio state promotion (e.g., promotion from idle state to connected state, promotion from low power state to high power state). This usually occurs when the inactivity timer, network dormancy timer or radio dormancy timer in the operator settings is set to a low value (e.g., 3 seconds). When a server response arrives after the inactivity timer has expired (e.g., after 4 seconds) and after the radio state is demoted to an idle state, the server response can cause the radio on the mobile device to be promoted to a connected state again.

As illustrated, during time period T_2, a number of data requests from one or more mobile applications are queued. The queued traffic **118***b* is then subsequently transferred to their respective destinations during time period T_1, after the radio is powered on. During the same time period T_2, at the network-side proxy, server initiated requests are queued, and the queued traffic **119***b* is sent to the mobile device during the interval T_1 when the radio is powered on.

In some instances, some of the incoming or outgoing traffic may be of high priority or may be time critical. For example, FIG. **1**A illustrates a high priority incoming traffic **119***c* arriving at the network-side proxy (e.g., network-side proxy **114** in FIGS. **1**C-**1**E and FIG. **3**). In such a case, the network-side proxy can cause the radio on the mobile device to power on, go up, get activated, get promoted or otherwise change to a different power state (e.g., a higher power or lower power state) after time period T_3, where the time period T_3 is shorter than T_2. The high priority incoming traffic **119***c* can then be transferred to the mobile device without delay. Since the radio is powered on, the local proxy on the mobile device can use the opportunity to transfer any queued outgoing traffic **118***c* during the interval T**1**. When the transfer is complete, the radio is powered down.

In some other instances, a change in the device state can occur (e.g., backlight turns on **118***d*), which can cause the radio on the mobile device to go up after time period T_4 where the time period T_4 is shorter than T_2. When the change in the radio state is detected, the local proxy can transfer any queued outgoing traffic **118***e* to their respective destinations, and the network-side proxy can similarly transfer any queued incoming traffic **119***d* to the mobile device.

It should be noted that the time periods T**1**-T**4** are shown for illustrative purposes only. These time periods may be configurable by the network operator or the network-side proxy (e.g., network-side proxy **114** in FIGS. **1**C-**1**E and FIG. **3**), the local proxy (e.g., local or client-side proxy **175** in FIGS. **1**C-**1**E and FIG. **2**A, and/or the proxy server (e.g., proxy server **125** in FIGS. **1**C-**1**E and FIG. **4**A). For example, the proxy server can deploy a policy which specifies the length of the interval for allowing incoming and outgoing traffic, length of the interval for delaying incoming and outgoing traffic, conditions under which certain types of traffic can be allowed, and the like. These time periods may also be changed on the fly, either on demand or based on one or more criteria such as screen on/off state, user activity, application foreground/background state, power level, and the like.

FIG. **1**B illustrates an example diagram of a system where a host server **100** facilitates management of traffic, content caching, and/or resource conservation between client devices **150** (e.g., mobile devices or wireless devices), an application server **110** or content provider, or other servers such as an ad server **120***a*, promotional content server **120***b*, or an e-coupon server **120***c* in a wireless network (or broadband network) for a distributed proxy system for enhancing mobile traffic management in the mobile network and resource conservation.

The client devices **150** can be any system and/or device, and/or any combination of devices/systems that is able to establish a connection, including wired, wireless, cellular connections with another device, a base station **112**, a server and/or other systems such as host server **100** and/or application server/content provider **110**. Client devices **150** will typically include a display and/or other output functionalities to present information and data exchanged among the client devices **150** and/or the host server **100** and/or application server/content provider **110**. The application server/content provider **110** can by any server including third party servers or service/content providers further including advertisement, promotional content, publication, or electronic coupon servers or services. Similarly, separate advertisement servers **120***a*, promotional content servers **120***b*, and/or e-Coupon servers **120***c* as application servers or content providers are illustrated by way of example.

The client devices **150** can include, for example, mobile, hand held or portable devices, wireless devices, or non-portable devices and can be any of, but not limited to, a server desktop, a desktop computer, a computer cluster, or portable devices including a notebook, a laptop computer, a handheld computer, a palmtop computer, a mobile phone, a cell phone, a smart phone, a PDA, a Blackberry device, a Palm device, any tablet, a phablet (a class of smart phones with larger screen sizes between a typical smart phone and a tablet), a handheld tablet (e.g., an iPad, the Galaxy series, the Nexus, the Kindles, Kindle Fires, any Android-based tablets, Windows-based tablets, or any other tablet), any portable readers/reading devices, a hand held console, a hand held gaming device or console, a head mounted device, a head mounted display, a thin client or any SuperPhone such as the iPhone, and/or any other portable, mobile, hand held devices, or fixed wireless interface such as a M2M device, wearable devices, mobile-enabled electronic glasses, mobile-enabled electronic watches, wireless-enabled glasses, wireless-enabled watches, wireless electronic glasses, wireless electronic watches, etc. In one embodiment, the client devices **150** (or mobile devices **150**), host server **100**, and application server **110** are coupled via a network **106** and/or a network **108**. In some embodiments, the devices **150** and host server **100** may be directly connected to one another.

The input mechanism on client devices **150** can include touch screen keypad (including single touch, multi-touch, gesture sensing in 2D or 3D, etc.), a physical keypad, a mouse, a pointer, a track pad, a stylus, a stylus detector/sensor/receptor, motion detector/sensor (e.g., including 1-axis, 2-axis, 3-axis accelerometer, etc.), a face detector/recognizer, a retinal detector/scanner, a light sensor, capacitance sensor, resistance sensor, temperature sensor, proximity sensor, a piezoelectric device, device orientation detector (e.g., electronic compass, tilt sensor, rotation sensor, gyroscope, accelerometer), or any combination of the above.

Signals received or detected indicating user activity at client devices **150** through one or more of the above input mechanism, or others, can be used in the disclosed technology in acquiring context awareness at the client device **150**. Context awareness at client devices **150** generally includes, by way of example but not limitation, client device **150** operation or state acknowledgement, management, user activity/behavior/interaction awareness, detection, sensing, tracking, trending, and/or application (e.g., mobile applications) type, behavior, activity, operating state, etc.

Context awareness in the present disclosure also includes knowledge and detection of network side contextual data and can include network information such as network capacity, bandwidth, traffic, type of network/connectivity, and/or any other operational state data. Network side contextual data can be received from and/or queried from network service providers (e.g., cell provider **112** and/or Internet service providers) of the network **106** and/or network **108** (e.g., by the host server and/or devices **150**). In addition to application context awareness as determined from the client **150** side, the application context awareness may also be received from or obtained/queried from the respective application/service providers **110** (by the host **100** and/or client devices **150**).

The host server **100** can use, for example, contextual information obtained for client devices **150**, networks **106/108**, applications (e.g., mobile applications), application server/provider **110**, or any combination of the above, to manage the traffic in the system to satisfy data needs of the client devices **150** (e.g., to satisfy application or any other request including HTTP request). In one embodiment, the traffic is managed by the host server **100** to satisfy data requests made in response to explicit or non-explicit user **103** requests and/or device/application maintenance tasks. The traffic can be managed such that network consumption, for example, use of the cellular network is conserved for effective and efficient bandwidth utilization. In addition, the host server **100** can manage and coordinate such traffic in the system such that use of device **150** side resources (e.g., including but not limited to battery power consumption, radio use, processor/memory use) are optimized with a general philosophy for resource conservation while still optimizing performance and user experience. The host server **100** may also indirectly manage traffic via creation, selection and/or deployment of traffic blocking policy for implementation on the mobile device in some embodiments.

For example, in context of battery conservation, the mobile device **150** can observe user activity (for example, by observing user keystrokes, backlight status, or other signals via one or more input mechanisms, etc.) and alter mobile device **150** behaviors. The mobile device **150** can also request the host server **100** to alter the behavior for network resource consumption based on user activity or behavior.

In one embodiment, traffic management for resource conservation is performed using a system distributed between the client device **150** and the network **106/108**. The distributed system can include proxy and cache components on the client device **150** side, and the network side **106/108**.

In another embodiment, the traffic management for resource conservation is performed using a system distributed between the host server **100** and the client device **150**. The distributed system can include a proxy server and cache components on the server side **100** and a local proxy and cache components on the device/client side, for example, as shown by the server cache **135** on the server **100** side and the local cache **185** on the client device **150** side.

In yet another embodiment, the traffic management for resource conservation is performed using a system distributed among the host server **100**, client device **150** and the network **106/108**. The distributed system can include proxy and/or cache components on the server side **100**, on the client device **150** side and on the network-side **106/108**.

Functions and techniques disclosed for context aware traffic management for resource conservation in networks (e.g., network **106** and/or **108**) and devices **150**, reside in a distributed proxy and cache system. The proxy and cache system can be distributed between, and reside on, a given client device **150** in part or in whole, the host server **100** in part or in whole and/or the network-side proxy in part or in whole. The distributed proxy and cache system are illustrated with further reference to the example diagram shown in FIG. **1**C. Functions and techniques performed by the proxy and cache components in the client device **150** and related components therein are described, respectively, in detail with further reference to the examples of FIGS. **2**A-**2**B. Similarly, functions and techniques performed by the proxy and/or cache components in the network **106** and related components therein are described, respectively, in detail with further reference to the examples of FIG. **3**. Functions and techniques performed by the proxy server and cache components in the host server **100** and related components are described in detail in the examples of FIGS. **4**A-**4**C.

In one embodiment, client devices **150** communicate with the host server **100** and/or the application server **110** over network **106**, which can be a cellular network and/or a broadband network. To facilitate overall traffic management between devices **150** and various application servers/content providers **110** to implement network (bandwidth utilization) and device resource (e.g., battery consumption), the host server **100** can communicate with the application server/providers **110** over the network **108**, which can include the Internet (e.g., a broadband network).

In general, the networks **106** and/or **108**, over which the client devices **150**, the host server **100**, and/or application server **110** communicate, may be a cellular network, a broadband network, a telephonic network, an open network, such as the Internet, or a private network, such as an intranet and/or the extranet, or any combination thereof. For example, the Internet can provide file transfer, remote log in, email, news, RSS, cloud-based services, instant messaging, visual voicemail, push mail, VoIP, and other services through any known or convenient protocol, such as, but is not limited to the TCP/IP protocol, UDP, HTTP, DNS, FTP, UPnP, NSF, ISDN, PDH, RS-232, SDH, SONET, etc.

The networks **106** and/or **108** include any collection of distinct networks operating wholly or partially in conjunction to provide connectivity to the client devices **150** and the host server **100** and may appear as one or more networks to the serviced systems and devices. In one embodiment, communications to and from the client devices **150** can be achieved by, an open network, such as the Internet, or a private network, broadband network, such as an intranet and/or the extranet. In one embodiment, communications can be achieved by a secure communications protocol, such as secure sockets layer (SSL), or transport layer security (TLS).

In addition, communications can be achieved via one or more networks, such as, but are not limited to, one or more of WiMax, a Local Area Network (LAN), Wireless Local Area Network (WLAN), a Personal area network (PAN), a Campus area network (CAN), a Metropolitan area network (MAN), a Wide area network (WAN), a Wireless wide area network (WWAN), or any broadband network, and further enabled with technologies such as, by way of example, Global System for Mobile Communications (GSM), Personal Communications Service (PCS), Bluetooth, WiFi, Fixed Wireless Data, 2G, 2.5G, 3G (e.g., WCDMA/UMTS based 3G networks), 4G, IMT-Advanced, pre-4G, LTE Advanced, mobile WiMax, WiMax 2, WirelessMAN-Advanced networks, enhanced data rates for GSM evolution (EDGE), General packet radio service (GPRS), enhanced GPRS, iBurst, UMTS, HSPDA, HSUPA, HSPA, HSPA+, UMTS-TDD, 1xRTT, EV-DO, messaging protocols such as, TCP/IP, SMS, MMS, extensible messaging and presence protocol (XMPP), real time messaging protocol (RTMP), instant messaging and presence protocol (IMPP), instant messaging, USSD, IRC, or any other wireless data networks, broadband networks, or messaging protocols.

FIG. **1**C illustrates an example diagram of a proxy and cache system distributed between the host server **100**, operator network **106** and a mobile device **150** which facilitates network traffic management between the mobile device **150**, an application server or content provider **110**, or other servers such as an ad server **120**A, promotional content server **120**B, or an e-coupon server **120**C for traffic management, resource conservation and content caching. The network-side proxy **114** in the operator network **106** can further enhance mobile traffic management and resource conservation in a mobile network.

The distributed proxy and cache system can include, for example, the proxy server **125** (e.g., remote proxy) and the server cache **135** components on the server side. The server-side proxy **125** and cache **135** can, as illustrated, reside internal to the host server **100**. In addition, the proxy server **125** and cache **135** on the server-side can be partially or wholly external to the host server **100** and in communication via one or more of the networks **106** and **108**. For example, the proxy server **125** may be external to the host server and the server cache **135** may be maintained at the host server **100**. Alternatively, the proxy server **125** may be within the host server **100** while the server cache is external to the host server **100**. In addition, each of the proxy server **125** and the cache **135** may be partially internal to the host server **100** and partially external to the host server **100**. The application server/content provider **110** can by any server including third party servers or service/content providers further including advertisement, promotional content, publication, or electronic coupon servers or services. Similarly, separate advertisement servers **120***a*, promotional content servers **120***b*, and/or e-Coupon servers **120***c* as application servers or content providers are illustrated by way of example.

The distributed system can also, include, in one embodiment, client-side components, including by way of example but not limitation, a local proxy **175** (e.g., a mobile client on a mobile device) and/or a local cache **185**, which can, as illustrated, reside internal to the device **150** (e.g., a mobile device).

In addition, the client-side proxy **175** and local cache **185** can be partially or wholly external to the device **150** and in communication via one or more of the networks **106** and **108**. For example, the local proxy **175** may be external to the device **150** and the local cache **185** may be maintained at the device **150**. Alternatively, the local proxy **175** may be within the device **150** while the local cache **185** is external to the device **150**. In addition, each of the proxy **175** and the cache **185** may be partially internal to the host server **100** and partially external to the host server **100**.

The distributed system can further include, in one embodiment, network-side components, including by way of example but not limitation, a network-side proxy **114** (e.g., a component in the operator network) and/or a network-side cache (not shown), which can, as shown, reside in the operator network **106**.

The network-side proxy **114** may be external to the mobile device **150**, the third-party servers (e.g., **110**, **120**A, **120**B, **120**C, and the like) and the host server **100**. In one embodiment, the network-side proxy **114** may reside in the operator's core network as an inline proxy through which all incoming/outgoing traffic to/from the mobile device is routed. In another embodiment, the network-side proxy **114** may reside in the radio access network, and may have knowledge of the radio state of the mobile device from the network, or from real time information provided by the local proxy **175** and/or the proxy server **125** regarding radio state promotions and demotions.

In one embodiment, the distributed system can include an optional caching proxy server **199**. The caching proxy server **199** can be a component which is operated by the application server/content provider **110**, the host server **100**, or a network service provider **112**, and or any combination of the above to facilitate network traffic management for network and device resource conservation. Proxy server **199** can be used, for example, for caching content to be provided to the device **150**, for example, from one or more of the application server/provider **110**, host server **100**, and/or a network service provider **112**. Content caching can also be entirely or partially performed by the remote proxy **125** to satisfy application requests or other data requests at the device **150**.

In context aware traffic management and optimization for resource conservation and/or congestion alleviation in a network (e.g., cellular or other wireless networks), characteristics of user activity/behavior and/or application behavior at a mobile device (e.g., any wireless device) **150** can be tracked by the local proxy **175** and communicated, over the network **106** to the proxy server **125** component in the host server **100**, for example, as connection metadata. The proxy server **125** which in turn is coupled to the application server/provider **110** provides content and data to satisfy requests made at the device **150**.

In addition, the local proxy **175** can identify and retrieve mobile device properties, including one or more of, battery level, network that the device is registered on, radio state, signal strength, cell identifier (i.e., cell ID), location area code, or whether the mobile device is being used (e.g., interacted with by a user). In some instances, the local proxy **175** can delay, expedite (pre-fetch), and/or modify data prior to transmission to the proxy server **125**, when appropriate, as will be further detailed with references to the description associated with the examples of FIG. **2**A.

The local cache **185** can be included in the local proxy **175** or coupled to the local proxy **175** and can be queried for a locally stored response to the data request prior to the data request being forwarded on to the proxy server **125**. Locally cached responses can be used by the local proxy **175** to satisfy certain application requests of the mobile device **150**, by retrieving cached content stored in the cache storage **185**, when the cached content is still valid.

Similarly, the proxy server **125** of the host server **100** can also delay, expedite, or modify data from the local proxy prior to transmission to the content sources (e.g., the application server/content provider **110**). In addition, the proxy server **125** uses device properties and connection metadata to generate rules for satisfying request of applications on the mobile device **150**. The proxy server **125** can gather real time traffic information about requests of applications for later use in optimizing similar connections with the mobile device **150** or other mobile devices. The proxy server **125** can further aggregate reports on detection of congestion from multiple mobile devices to provide reports on congestion distribution and timing patterns and other information to operators of the networks.

In general, the local proxy **175**, the proxy server **125** and/or the network-side proxy **114** are transparent to the multiple applications executing on the mobile device. The local proxy **175** is generally transparent to the operating system or platform of the mobile device and may or may not be specific to device manufacturers. In some instances, the local proxy **175** is optionally customizable in part or in whole to be device specific. In some embodiments, the local proxy **175** may be bundled into a wireless model, a firewall, and/or a router. Similarly, the network-side proxy **114** can be customizable in part on in whole to be network operator specific. For example, traffic management policies for one network operator may be different from policies for another network operator.

In one embodiment, the host server **100** can in some instances, utilize the store and forward functions of a short message service center (SMSC) **112**, such as that provided by the network service provider in communicating with the device **150** in achieving network traffic management. Note that SMSC **112** can also utilize any other type of alternative channel including USSD or other network control mechanisms. The host server **100** can forward content or HTTP responses to the SMSC **112** such that it is automatically forwarded to the client device **150** if available, and for subsequent forwarding if the client device **150** is not currently available.

In general, the disclosed distributed proxy and cache system allows optimization of network usage, for example, by serving requests from the local cache **185**, the local proxy **175** reduces the number of requests that need to be satisfied over the network **106**. Further, the local proxy **175** and the proxy server **125** may filter irrelevant data from the communicated data. In addition, the local proxy **175**, the proxy server **125** and/or the network-side proxy **114** can also accumulate background requests and low priority data and send it in batches to avoid the protocol overhead of sending individual data fragments and establishing data connections. The local proxy **175**, the network-side proxy **114** and/or the proxy server **125** can also compress or transcode the traffic, reducing the amount of data sent over the network **106** and/or **108**. The network-side proxy can further block unnecessary data (e.g., during socket closure) from reaching the mobile device and causing the radio on the mobile device to turn on. The network-side proxy can also supply cached responses to third-party servers to keep the servers happy, and prevent them from retrying. The signaling traffic in the network **106** and/or **108** can be reduced, as the networks are now used less often and the network traffic can be synchronized among individual applications.

With respect to the battery life of the mobile device **150**, by serving application or content requests from the local cache **185**, the local proxy **175** can reduce the number of times the radio module is powered up. The local proxy **175**, the network-side proxy **114** and the proxy server **125** can work in conjunction to accumulate background requests and other low priority data and send such data in batches to reduce the number of times and/or length of time when the radio is powered up. The local proxy **175** can synchronize the network use by performing the batched data transfer for all connections simultaneously.

FIG. **1**D illustrates an example diagram of the logical architecture of a distributed proxy and cache system which can include components such as a client-side proxy **175**, a server-side proxy **125**, a network-side proxy **114** and a log storage and processing service **174**. Some example components of the distributed proxy and cache system are described as follows:

Client Side Proxy **175**: A component installed in a smartphone, mobile device or wireless device **150** that interfaces with device's operating system, as well as with data services and applications installed in the device. The client side proxy **175** is typically compliant with and able to operate with standard or state of the art networking protocols. Additional components and features of the client-side proxy **175** are illustrated with further references to the examples of FIGS. **2**A-**2**B.

Network-Side Proxy **114**: A component in the operator network **152** (the core network or the radio access network **112**) that interfaces with mobile devices **150**, third-party servers (e.g., application server/content providers **110**, caching proxy server **199**) and server-side proxy **125**. The network-side proxy **114** can be configured as the last node for incoming traffic, before the incoming traffic reaches the radio modem on the mobile device. The network-side proxy **114** is typically compliant with and able to operate with standard or state of the art networking protocols and/or other requirements specific to the network operator. Additional components and features of the network-side proxy **114** are illustrated with further references to the examples of FIG. **3**.

The server side proxy **125** can include one or more servers that can interface with third party application servers (which can be proxy **199** or other servers that is not illustrated), the client-side proxy **175** and/or the network-side proxy **114**. In general, the server side proxy **125** can be compliant with and is generally able to operate with standard or state of the art networking protocols and/or specifications for interacting with mobile network elements and/or third party servers. Some components and features of the server-side proxy **125** are illustrated with further references to the examples of FIG. **1**G and FIGS. **4**A-**4**C.

Log Storage and Processing Service (LSPS) **174**: The log storage and processing service, server, system or component **174** can provide reporting and usage analytics services. The LSPS **174** can collect information (e.g., logs) from the client side proxy **175**, the network-side proxy **114** and/or the server side proxy **125** and provide the necessary tools for producing reports and usage analytics can used for analyzing traffic and signaling data or behavior across applications, servers, and the like. The client logs (e.g., logs on the client device **150** aggregated by the local proxy **175**) are stored in the device until a data channel is activated, and then are transferred in binary format to the LSPS **174**. In one embodiment, the logs are processed using log processing tools provided by the LSPS **174**. The processed logs are subsequently stored in a distributed database. The logs may be used for reporting as well as for troubleshooting issues. For example, analytics from the logs can be used by the proxy system in managing, reducing or optimizing network traffic or by the network operator in monitoring their networks for possible improvements and enhancements. Note that LSPS **174** as illustrated may be a server separate from the server-side proxy **125**, or it may be a component of the server-side proxy **125** residing partially or wholly therein.

In one implementation, the level of logging (e.g., types of data to be logged, and the like) can be specified using configuration settings in the client-side proxy **175**, the network-side proxy **114** and/or the server-side proxy **125**. Various data relating to bytes and transactions, network connectivity, power, subscriber count, and the like may be logged, and/or processed using default (or another) settings on a periodic (e.g., hourly, daily, and the like) basis.

Bytes and Transactions data may include a number of bytes transacted (both to and from), total number of transactions between the client-side proxy **175** and each application, the client-side proxy **175** and the network (e.g., radio access network **112**), the client-side proxy **175** and its cache, and the like. Network Connectivity data may include, for example, total time the device spends in "data connected" state (based on a two-state connectivity model), total number of transitions into the data connected state, the number of times the radio transitions into the data connected state due to a network request that was proxied through the client-side proxy **175**, total time spent in the data connected state due to a network request that was proxied through the client-side proxy **175**, the number of transitions into data connected mode saved by the client-side and/or server-side proxy system, the amount of time in data connected state saved by the client-side and/or server-side proxy system and simulated values for the previous four items, as if traffic proxied via client-side and/or server-side proxy system were the only traffic on the device. Network connectivity data can also include the amount of time taken to transition from an idle state to connected state (i.e., setup time), a baseline or a reference determined from a sample of setup times, and the like. Power related data may include, for example, each one-percent (or any other percentage value) change in the battery level, the total time the device is powered on but not connected to a power source, and the like. Subscriber count data may include, for example, the number of new subscribers observed in a period and the number of active subscribers in the period. This data may be aggregated by the host server, for example. Reporting of the above data can be done based on variables such as network bearer type (e.g., all, mobile or Wi-Fi), category (e.g., all, device model or application name), time (e.g., hour, day or month), and the like, or combinations thereof.

FIG. **1**E illustrates an example diagram of the logical architecture of a distributed proxy and cache system comprising six sockets distributed over a client-side proxy **175**, a network-side proxy **114** and a server-side proxy **125** to enhance mobile traffic management in a mobile network. As illustrated, a mobile device **150** includes an application **163** that is in communication with a client-side proxy **175** having a local cache **185**. The client-side proxy **175** is in communication with a network-side proxy **114**, which is in communication with a third-party server **110** (e.g., an application server/content provider **110**, ad server **120***a*, promotional content server **120***b* or e-coupon server **120***c* in FIGS. **1**B and **1**C) and a server-side proxy **125** having a server cache **116**. Each component's socket end is identified in FIG. **1**E by a corresponding socket number S**1**-S**6** and A-B. Each socket end has its own timeout or tolerance (e.g., TCP (Transport Control Protocol) timeout). The timeouts in some of these sockets can be controlled for managing traffic and consequently for conserving resources.

For example, S**1** is a socket utilized, managed and/or controlled by the application **163**. The local proxy **175** can overwrite the properties of S**1** (e.g., timeout settings such as timeout for reading data on already established socket and/or timeout for establishing the socket). As a consequence, the application **163** can tolerate delays in sending requests or receiving responses, without timing out. Thus, the socket S**1** is controllable, manipulable and/or configurable/reconfigurable by the local proxy **175**.

S**2** and S**3** are sockets managed and/or controlled by the local proxy **175**, are also controllable, manipulable and/or configurable/reconfigurable by the local proxy **175**. For example, the local proxy **175** can also modify the timeout settings for S**2** and S**3** and thus delay requests from the application **163** along with requests from any other applications on the mobile device **150**. By having control over S**1**-S**3**, the local proxy **175** can effectively intercept outgoing requests from multiple applications on the mobile device and accumulate those outgoing requests such that multiple outgoing requests from multiple applications can be sent out at the same time, using the same radio connection to the mobile network.

S**4** and S**5** are sockets utilized, managed and/or controlled by the network-side proxy **114** and therefore controllable, manipulable and/or configurable/reconfigurable by the network-side proxy **114**. Having control over S**4** and S**5** means that incoming requests from the third-party server **110** (e.g., requests initiated from third party server **110**, response from third-party server **110** to a request from the mobile device **150**) can be intercepted by and accumulated at the network-side proxy **114**. The network-side proxy **114** and the local proxy **175** can then coordinate with each other such that the transfer of the accumulated incoming requests from the network-side proxy **114** to the mobile device and transfer of the outgoing requests from the mobile device to one or more third-party servers via the network-side proxy **114** occur during an agreed or determined interval of time, using the same radio connection to the mobile network.

S**6** is a socket utilized, managed and/or controlled by the third-party server **110**, and therefore, in some instance, may be beyond the control of the local proxy **175**, the network-side proxy **114** and/or the server-side proxy **125**. Typically third-party servers tend to timeout and close the TCP connection if they do not hear anything from the client. By terminating an idle TCP connection, third-party servers can save on system memory and other resources. For example, if the third-party server **110** is waiting for a keepalive packet, but does not receive any such packet from application **163** on the mobile device **150**, the third-party server **110** can terminate the TCP connection to save on resources. A TCP connection is usually terminated by sending a FIN packet. In some cases, third party servers can generate and send some data to test the TCP connection or can attempt a number of retries based on a backoff algorithm. These data packets from the activities on the third-party server **110** can cause extra signaling in the mobile network. However, since S**6** usually cannot be controlled by the network-side proxy **114** or the server-side proxy **125**, it is usually not possible to prevent the third-party server from sending these packets.

The network-side proxy **114** can, in an embodiment, intercept and prevent such data from third-party servers from being delivered to the mobile device to save on signaling. In a further embodiment, the network-side proxy **114** can determine whether the data from third-party servers is unnecessary, and if so, block the data from being sent to the mobile device when a radio connection is not established. In some embodiments, the network-side proxy **114** can categorize certain types of data as unnecessary based on a policy. For example, data relating to socket closures or data relating to testing of a connection, acknowledgements, and the like can be considered unnecessary when a radio on the mobile device is idle, or regardless of the radio state. For example, if the third-party server **110** sends a FIN packet to terminate a TCP connection when a radio on the mobile device is idle (i.e., TCP connection is already terminated), the FIN packet can be categorized as unnecessary data and blocked from being delivered at that instant. The unnecessary data may also be permanently blocked from being delivered in some cases.

In some embodiments, the network-side proxy **114** can further keep third party servers in an unaware or content state by providing safe responses (e.g., cached responses) to requests, without having to send the requests to the mobile device. For example, when the third-party server **110** generates and sends some data to test a TCP connection, the network-side proxy **114** can respond with a cached response (e.g., an ACK or other expected response). The cached response from the network-side proxy **114** can placate the third-party server **110** and prevent the third-party server from, for example, assuming that the TCP connection is idle and in response, terminating the TCP connection.

FIG. **1**F illustrates an example diagram showing the architecture of client side components in a distributed proxy and cache system.

The client side proxy **175** can include software components or agents installed on the mobile device that enable traffic optimization and perform the related functionalities on the client side. Components of the client side proxy **175** can operate transparently for end users and applications **163**, and interface with the device's operating system (OS) **162**. The client side proxy **175** can be installed on mobile devices for optimization to take place, and it can effectuate changes on the data routes and/or timing. Once data routing is modified, the client side proxy **175** can respond to application requests to service providers or host servers, in addition to or instead of letting those applications **163** access data network directly. In general, applications **163** on the mobile device will not notice that the client side proxy **175** is responding to their requests.

Some example components of the client side proxy **175** are described as follows:

Device State Monitor **121**: The device state monitor **121** can be responsible for identifying several states and metrics in the device, such as network status, display status, battery level (e.g., via the radio/battery information **161**), etc., such that the remaining components in the client side proxy **175** can operate and make decisions according to device state, acting in an optimal way in each state.

Traffic Recognizer **122**: The traffic recognizer **122** analyzes all traffic between the wireless device applications **163** and their respective host servers in order to identify recurrent patterns. Supported transport protocols include, for example, DNS, HTTP and HTTPS, such that traffic through those ports is directed to the client side proxy **175**. While analyzing traffic, the client side proxy **175** can identify recurring polling patterns which can be candidates to be performed remotely by the server side proxy **125**, and send to the protocol optimizer **123**.

Protocol Optimizer **123**: The protocol optimizer **123** can implement the logic of serving recurrent requests from the local cache **185** instead of allowing those requests to go over the network to the service provider/application host server. One of its tasks is to eliminate or minimize the need to send requests to the network, positively affecting network congestion and device battery life.

Local Cache **185**: The local cache **185** can store responses to recurrent requests, and can be used by the Protocol Optimizer **123** to send responses to the applications **163**.

Traffic Scheduler **124**: The traffic scheduler **124** can temporally move communications to optimize usage of device resources by unifying keep-alive signaling so that some or all of the different applications **163** can send keep-alive messages at the same time (traffic pipelining). Traffic scheduler **124** may also decide to delay transmission of data that is not relevant at a given time (for example, when the device is not actively used).

Policy Manager **125**: The policy manager **125** can store and enforce traffic management and/or optimization and/or reporting policies provisioned by a Policy Management Server (PMS). At the client side proxy **175** first start, traffic management and/or optimization and reporting policies (policy profiles) that is to be enforced in a particular device can be provisioned by the Policy Management Server. Enforcing traffic management policies at the device's IP layer lets an operator manage traffic before it uses radio accessed network resources. Policy usage can range from creating highly targeted subscriber plans to proactively and/or reactively managing network congestion. In one implementation, the conditions for selecting a policy for enforcement, and/or conditions for dropping an implemented policy may be managed or coordinated by the policy manager **125**.

Watch Dog **127**: The watch dog **127** can monitor the client side proxy **175** operating availability. In case the client side proxy **175** is not working due to a failure or because it has been disabled, the watchdog **127** can reset DNS routing rules information and can restore original DNS settings for the device to continue working until the client side proxy **175** service is restored.

Reporting Agent **126**: The reporting agent **126** can gather information (e.g., logs) about the events taking place in the device and sends the information to the log storage and processing service **174**, which collects and stores client-side and/or server-side proxy system logs. Event details are stored temporarily in the device and transferred to log storage and processing service **174** only when the data channel state is active. If the client side proxy **175** does not send records within a period of time (e.g., twenty-four hours), the reporting agent **126** may, in one embodiment, attempt to open the connection and send recorded entries or, in case there are no entries in storage, an empty reporting packet. All reporting settings may be configured in the policy management server. The information in the logs may be used for reporting and/or troubleshooting, for example.

Push Client **128**: The push client **128** can be responsible for the traffic between the server side proxy **125** and the client side proxy **175**. The push client **128** can send out service requests like content update requests and policy update requests, and receives updates to those requests from the server side proxy **125**. In addition, push client **128** can send data to a log storage and processing service **176**, which may be internal to or external to the server side proxy **125**.

FIG. **1**G illustrates a diagram of example components on a server side of a distributed proxy and cache system.

The server side **125** of the distributed system can include, for example a relay server **142**, which interacts with a traffic harmonizer **144**, a polling server **145** and/or a policy management server **143**. Each of the various components can communicate with the client side proxy **175**, the network-side proxy **114** or other third party (e.g., application server/service provider **110** and/or other proxy **199**) and/or a the LSPS **174**. Some example components of the server side proxy **125** is described as follows:

Relay Server **142**: The relay server **142** is the routing agent in the distributed proxy architecture. The relay server **142** manages connections and communications with components on the client-side proxy **175** installed on devices and provides an administrative interface for reports (e.g., congestion reports), provisioning, platform setup, and so on.

Notification Server **141**: The notification server **141** is a module able to connect to an operator's SMSC gateways and deliver SMS notifications to the client-side proxy **175**. SMS notifications can be used when an IP link is not currently active, in order to avoid the client-side proxy **175** from activating a connection over the wireless data channel, thus avoiding additional signaling traffic. However, if the IP connection happens to be open for some other traffic, the notification server **141** can use it for sending the notifications to the client-side proxy **175**. The user database can store operational data including endpoint (MSISDN), organization and Notification server **141** gateway for each resource (URIs or URLs).

Traffic Harmonizer **144**: The traffic harmonizer **144** can be responsible for communication between the client-side proxy **175** and the polling server **145**. The traffic harmonizer **144** connects to the polling server **145** directly or through the data storage **130**, and to the client over any open or proprietary protocol such as the 7TP, implemented for traffic optimization. The traffic harmonizer **144** can be also responsible for traffic pipelining on the server side: if there's cached content in the database for the same client, this can be sent over to the client in one message.

Polling Server **145**: The polling server **145** can poll third party application servers on behalf of applications that are being optimized). If a change occurs (i.e. new data available) for an application, the polling server **145** can report to the traffic harmonizer **144** which in turn sends a notification message to the client-side proxy **175** for it to clear the cache and allow application to poll application server directly.

Policy Management Server **143**: The policy management server (PMS) **143** allows administrators to configure and store policies for the client-side proxies **175** (e.g., mobile device policies). It also allows administrators to notify the client-side proxies **175** about policy changes. In some embodiments, the PMS **143** allows administrators to configure and store policies for network-side proxies **114** (e.g., operator policies). For example, using the policy management server **143**, each operator can configure the policies to work in the most efficient way for the unique characteristics of each particular mobile operator's network.

Log Storage and Processing Service **174**: The log storage and processing service **174** collects information (e.g., logs) from the client side **175** and/or from the server side **125**, and provides the tools for analyzing and producing reports and usage analytics that network operators can use for analyzing application signaling (e.g., determine percent reduction in application signaling), data consumption, congestion, improvement in battery performance, and the like.

The proxy server **199** has a wide variety of uses, from speeding up a web server by caching repeated requests, to caching web, DNS and other network lookups for a group of clients sharing network resources. The proxy server **199** is optional. The distributed proxy and cache system (**125** and/or **175**) allows for a flexible proxy configuration using either the proxy **199**, additional proxy(s) in operator's network, or integrating both proxies **199** and an operator's or other third-party's proxy.

FIG. **2**A illustrates a block diagram depicting an example of client-side components in a distributed proxy and cache system, including components for managing outgoing traffic from multiple applications on a mobile device **250** to enhance mobile traffic management and resource conservation in a mobile network.

The mobile device **250**, which can be a device that is portable or mobile (e.g., any wireless device), such as a portable phone, generally includes, for example, a network interface **208**, an operating system **204**, a context API **206**, and mobile applications which may be proxy-unaware **210** or proxy-aware **220**. Note that the client device **250** is specifically illustrated in the example of FIG. **2**A as a mobile device, such is not a limitation and that mobile device **250** may be any wireless, broadband, portable/mobile or non-portable device able to receive, transmit signals to satisfy data requests over a network including wired or wireless networks (e.g., Wi-Fi, cellular, Bluetooth, LAN, WAN, and the like).

The network interface **208** can be a networking module that enables the device **250** to mediate data in a network with an entity that is external to the host server **250** through any known and/or convenient communications protocol supported by the host and the external entity. The network interface **208** can include one or more of a network adaptor card, a wireless network interface card (e.g., SMS interface, Wi-Fi interface, interfaces for various generations of mobile communication standards including but not limited to 2G, 3G, 3.5G, 4G, LTE, and the like), Bluetooth, or whether or not the connection is via a router, an access point, a wireless router, a switch, a multilayer switch, a protocol converter, a gateway, a bridge, a bridge router, a hub, a digital media receiver, and/or a repeater.

The mobile device **250** can further include, client-side components of the distributed proxy and cache system which can include, a local proxy **175** (e.g., a mobile client of the mobile device **250**) and a cache **285**. In one embodiment, the local proxy **175** includes a user activity module **215**, a proxy API **225**, a request/transaction manager **235**, a caching policy manager **245** having an application protocol module **248**, a traffic management policy module **249**, a traffic shaping engine **255**, a connection manager **265**, a radio state management engine **204** and/or a radio state change notification engine **202**. The traffic shaping engine **255** may further include an alignment module **256** and/or a batching module **257**, the connection manager **265** may further include a radio controller **266** and a heartbeat manager **267**. The request/transaction manager **235** can further include an application behavior detector **236** and/or a prioritization engine **241**, the application behavior detector **236** may further include a pattern detector **237** and/or and application profile generator **239**.

In one embodiment, a portion of the distributed proxy and cache system for mobile traffic management resides in or is in communication with the mobile device **250**, including local proxy **175** (mobile client) and/or cache **285**. The local proxy **175** can provide an interface on the mobile device **250** for users to access device applications and services including email, IM, voice mail, visual voicemail, feeds, Internet, games, productivity tools, or other applications, etc.

The local proxy **175** is generally application independent and can be used by applications (e.g., both proxy-aware and proxy-unaware applications **210** and **220** and other mobile applications) to open TCP (Transport Control Protocol) or other protocol based connections to a remote server (e.g., the server **100** in the examples of FIG. **1**B-**1**C and/or server proxy **125** shown in the examples of FIG. **1**B. In some instances, the local proxy **175** includes a proxy API **225** which can be optionally used to interface with proxy-aware applications **220** (or applications (e.g., mobile applications) on a mobile device (e.g., any wireless device)).

The applications **210** and **220** can generally include any user application, widgets, software, HTTP-based application, web browsers, video or other multimedia streaming or downloading application, video games, social network applications, email clients, RSS management applications, application stores, document management applications, productivity enhancement applications, and the like. The applications can be provided with the device OS, by the device manufacturer, by the network service provider, downloaded by the user, or provided by others.

One embodiment of the local proxy **175** includes or is coupled to a context API **206**, as shown. The context API **206** may be a part of the operating system **204** or device platform or independent of the operating system **204**, as illustrated. The operating system **204** can include any operating system including but not limited to, any previous, current, and/or future versions/releases of, Windows Mobile, iOS, Android, Symbian, Palm OS, Brew MP, Java 2 Micro Edition (J2ME), Blackberry, etc.

The context API **206** may be a plug-in to the operating system **204** or a particular client/application on the device **250**. The context API **206** can detect signals indicative of user or device activity, for example, sensing motion, gesture, device location, changes in device location, device backlight, keystrokes, clicks, activated touch screen, mouse click or detection of other pointer devices. The context API **206** can be coupled to input devices or sensors on the device **250** to identify these signals. Such signals can generally include input received in response to explicit user input at an input device/mechanism at the device **250** and/or collected from ambient signals/contextual cues detected at or in the vicinity of the device **250** (e.g., light, motion, piezoelectric, etc.).

In one embodiment, the user activity module **215** interacts with the context API **206** to identify, determine, infer, detect, compute, predict, and/or anticipate, characteristics of user activity on the device **250**. Various inputs collected by the context API **206** can be aggregated by the user activity module **215** to generate a profile for characteristics of user activity. Such a profile can be generated by the user activity module **215** with various temporal characteristics. For instance, user activity profile can be generated in real-time for a given instant to provide a view of what the user is doing or not doing at a given time (e.g., defined by a time window, in the last minute, in the last 30 seconds, etc.), a user activity profile can also be generated for a 'session' defined by an application or web page that describes the characteristics of user behavior with respect to a specific task they are engaged in on the mobile device **250**, or for a specific time period (e.g., for the last 2 hours, for the last 5 hours).

Additionally, characteristic profiles can be generated by the user activity module **215** to depict a historical trend for user activity and behavior (e.g., 1 week, 1 mo., 2 mo., etc.). Such historical profiles can also be used to deduce trends of user behavior, for example, access frequency at different times of day, trends for certain days of the week (weekends or week days), user activity trends based on location data (e.g., IP address, GPS, or cell tower coordinate data) or changes in location data (e.g., user activity based on user location, or user activity based on whether the user is on the go, or traveling outside a home region, etc.) to obtain user activity characteristics.

In one embodiment, user activity module **215** can detect and track user activity with respect to applications, documents, files, windows, icons, and folders on the device **250**. For example, the user activity module **215** can detect when an application or window (e.g., a web browser or any other type of application) has been exited, closed, minimized, maximized, opened, moved into the foreground or into the background, multimedia content playback, etc.

In one embodiment, characteristics of the user activity on the device **250** can be used to locally adjust behavior of the device (e.g., mobile device or any wireless device) to optimize its resource consumption such as battery/power consumption and more generally, consumption of other device resources including memory, storage, and processing power, and/or further optimize signaling in the network. In one embodiment, the use of a radio on a device can be adjusted based on characteristics of user behavior (e.g., by the radio controller **266** of the connection manager **265**) coupled to the user activity module **215**. For example, the radio controller **266** can turn the radio on or off, based on characteristics of the user activity on the device **250**. In addition, the radio controller **266** can adjust the power mode of the radio (e.g., to be in a higher power mode or lower power mode) depending on characteristics of user activity.

In one embodiment, characteristics of the user activity on device **250** can also be used to cause another device (e.g., other computers, a mobile device, a wireless device, or a non-portable device) or server (e.g., host server **100** in the examples of FIG. **1**B-**1**C) which can communicate (e.g., via a cellular or other network) with the device **250** to modify its communication frequency with the device **250**. The local proxy **175** can use the characteristics information of user behavior determined by the user activity module **215** to instruct the remote device as to how to modulate its communication frequency (e.g., decreasing communication frequency, such as data push frequency if the user is idle, requesting that the remote device notify the device **250** if new data, changed, data, or data of a certain level of importance becomes available, etc.).

In one embodiment, the user activity module **215** can, in response to determining that user activity characteristics indicate that a user is active after a period of inactivity, request that a remote device (e.g., server host server **100** or the network-side proxy **114** in the examples of FIG. **1**B-**1**C) send the data that was buffered as a result of the previously decreased communication frequency.

In addition, or in alternative, the local proxy **175** can communicate the characteristics of user activity at the device **250** to the remote device (e.g., host server **100** or the network-side proxy **114** in the examples of FIG. **1**B-**1**C) and the remote device determines how to alter its own communication frequency with the device **250** for network resource conservation and conservation of resources of the mobile device **250**.

One embodiment of the local proxy **175** further includes a request/transaction manager **235**, which can detect, identify, intercept, process, manage, data requests initiated on the device **250**, for example, by applications **210** and/or **220**, and/or directly/indirectly by a user request. Such data requests can be asynchronous requests. The request/transaction manager **235** can determine how and when to process a given request or transaction, or a set of requests/transactions, based on transaction characteristics.

The request/transaction manager **235** can prioritize requests or transactions made by applications and/or users at the device **250**, for example by the prioritization engine **241**. Importance or priority of requests/transactions can be determined by the request/transaction manager **235** by applying a rule set, for example, according to time sensitivity of the transaction, time sensitivity of the content in the transaction, time criticality of the transaction, time criticality of the data transmitted in the transaction, and/or time criticality or importance of an application making the request.

In addition, transaction characteristics can also depend on whether the transaction was a result of user-interaction or other user-initiated action on the device (e.g., user interaction with an application (e.g., a mobile application)). In general, a time critical transaction can include a transaction resulting from a user-initiated data transfer, and can be prioritized as such. Transaction characteristics can also depend on the amount of data that will be transferred or is anticipated to be transferred as a result of the requested transaction. For example, the connection manager **265**, can adjust the radio mode (e.g., high power or low power mode via the radio controller **266**) based on the amount of data that will need to be transferred.

In addition, the radio controller **266**/connection manager **265** can adjust the radio power mode (high or low) based on time criticality/sensitivity of the transaction. The radio controller **266** can trigger the use of high power radio mode when a time-critical transaction (e.g., a transaction resulting from a user-initiated data transfer, an application running in the foreground, any other event meeting a certain criteria) is initiated or detected.

In general, the priorities can be set by default, for example, based on device platform, device manufacturer, operating system, etc. Priorities can alternatively or additionally be set by the particular application; for example, the Facebook application (e.g., a mobile application) can set its own priorities for various transactions (e.g., a status update can be of higher priority than an add friend request or a poke request, a message send request can be of higher priority than a message delete request), an email client or IM chat client may have its own configurations for priority. The prioritization engine **241** may include set of rules for assigning priority.

The prioritization engine **241** can also track network provider limitations or specifications on application or transaction priority in determining an overall priority status for a request/transaction. Furthermore, priority can in part or in whole be determined by user preferences, either explicit or implicit. A user, can in general, set priorities at different tiers, such as, specific priorities for sessions, or types, or applications (e.g., a browsing session, a gaming session versus an IM chat session, the user may set a gaming session to always have higher priority than an IM chat session, which may have higher priority than web-browsing session). A user can set application-specific priorities, (e.g., a user may set Facebook-related transactions to have a higher priority than LinkedIn-related transactions), for specific transaction types (e.g., for all send message requests across all applications to have higher priority than message delete requests, for all calendar-related events to have a high priority, etc.), and/or for specific folders.

The prioritization engine **241** can track and resolve conflicts in priorities set by different entities. For example, manual settings specified by the user may take precedence over device OS settings, network provider parameters/limitations (e.g., set in default for a network service area, geographic locale, set for a specific time of day or set based on service/fee type) may limit any user-specified settings and/or application-set priorities. In some instances, a manual synchronization request received from a user can override some, most, or all priority settings in that the requested synchronization is performed when requested, regardless of the individually assigned priority or an overall priority ranking for the requested action.

Priority can be specified and tracked internally in any known and/or convenient manner, including but not limited to, a binary representation, a multi-valued representation, and a graded representation and all are considered to be within the scope of the disclosed technology.

TABLE I

Change (initiated on device)	Priority
Send email	High
Delete email	Low
(Un)read email	Low
Move message	Low
Read more	High
Download attachment	High
New Calendar event	High
Edit/change Calendar event	High
Add a contact	High
Edit a contact	High
Search contacts	High
Change a setting	High
Manual send/receive	High
IM status change	Medium
Auction outbid or change notification	High
Weather Updates	Low
Receive email	High
Edit email	Often not possible to sync (Low if possible)
New email in deleted items	Low
Delete an email	Low
(Un)Read an email	Low
Move messages	Low
Any calendar change	High
Any contact change	High
Wipe/lock device	High
Settings change	High
Any folder change	High
Connector restart	High (if no changes nothing is sent)
Social Network Status Updates	Medium
Severe Weather Alerts	High
News Updates	Low

Table I above shows, for illustration purposes, some examples of transactions with examples of assigned priorities in a binary representation scheme. Additional assignments are possible for additional types of events, requests, transactions, and as previously described, priority assignments can be made at more or less granular levels (e.g., at the session level or at the application level, etc.).

As shown by way of example in the above table, in general, lower priority requests/transactions can include, updating message status as being read, unread, deleting of messages, deletion of contacts; higher priority requests/transactions, can in some instances include, status updates, new IM chat message, new email, calendar event update/cancellation/deletion, an event in a mobile gaming session, or other entertainment related events, a purchase confirmation through a web purchase or online, request to load additional or download content, contact book related events, a transaction to change a device setting, location-aware or location-based events/transactions, or any other events/request/transactions initiated by a user or where the user is known to be, expected to be, or suspected to be waiting for a response, etc.

Inbox pruning events (e.g., email, or any other types of messages), are generally considered low priority and absent other impending events, generally will not trigger use of the radio on the device **250**. Specifically, pruning events to remove old email or other content can be 'piggy backed' with other communications if the radio is not otherwise on, at the time of a scheduled pruning event. For example, if the user has preferences set to 'keep messages for 7 days old,' then instead of powering on the device radio to initiate a message delete from the device **250** the moment that the message has exceeded 7 days old, the message is deleted when the radio is powered on next. If the radio is already on, then pruning may occur as regularly scheduled.

The request/transaction manager **235**, can use the priorities for requests (e.g., by the prioritization engine **241**) to manage outgoing traffic from the device **250** for resource optimization (e.g., to utilize the device radio more efficiently for battery conservation). For example, transactions/requests below a certain priority ranking may not trigger use of the radio on the device **250** if the radio is not already switched on, as controlled by the connection manager **265**. In contrast, the radio controller **266** can turn on the radio such a request can be sent when a request for a transaction is detected to be over a certain priority level.

In one embodiment, priority assignments (such as that determined by the local proxy **175** or another device/entity) can be used cause a remote device to modify its communication with the frequency with the mobile device or wireless device. For example, the remote device can be configured to send notifications to the device **250** when data of higher importance is available to be sent to the mobile device or wireless device.

In one embodiment, transaction priority can be used in conjunction with characteristics of user activity in shaping or managing traffic, for example, by the traffic shaping engine **255**. For example, the traffic shaping engine **255** can, in response to detecting that a user is dormant or inactive, wait to send low priority transactions from the device **250**, for a period of time. In addition, the traffic shaping engine **255** can allow multiple low priority transactions to accumulate for batch transferring from the device **250** (e.g., via the batching module **257**). In one embodiment, the priorities can be set, configured, or readjusted by a user. For example, content depicted in Table I in the same or similar form can be accessible in a user interface on the device **250** and, for example, used by the user to adjust or view the priorities.

The batching module **257** can initiate batch transfer based on certain criteria. For example, batch transfer (e.g., of multiple occurrences of events, some of which occurred at different instances in time) may occur after a certain number of low priority events have been detected, or after an amount of time elapsed after the first of the low priority event was initiated. In addition, the batching module **257** can initiate batch transfer of the accumulated low priority events when a higher priority event is initiated or detected at the device **250**. Batch transfer can otherwise be initiated when radio use is triggered for another reason (e.g., to receive data from a remote device such as host server **100**, network-side proxy **114**). In one embodiment, an impending pruning event (pruning of an inbox), or any other low priority events, can be executed when a batch transfer occurs.

In general, the batching capability can be disabled or enabled at the event/transaction level, application level, or session level, based on any one or combination of the following: user configuration, device limitations/settings, manufacturer specification, network provider parameters/limitations, platform-specific limitations/settings, device OS settings, etc. In one embodiment, batch transfer can be initiated when an application/window/file is closed out, exited, or moved into the background; users can optionally be prompted before initiating a batch transfer; users can also manually trigger batch transfers.

In one embodiment, the local proxy **175** locally adjusts radio use on the device **250** by caching data in the cache **285**. When requests or transactions from the device **250** can be satisfied by content stored in the cache **285**, the radio controller **266** need not activate the radio to send the request to a remote entity (e.g., the host server **100**, **300**, as shown in FIG. **1**B and FIGS. **4**A-**4**C or a content provider/application server such as the server/provider **110** shown in the examples of FIGS. **1**B-**1**C). As such, the local proxy **175** can use the local cache **285** and the cache policy manager **245** to locally store data for satisfying data requests to eliminate or reduce the use of the device radio for conservation of network resources and device battery consumption.

In leveraging the local cache, once the request/transaction manager **225** intercepts a data request by an application on the device **250**, the local repository **285** can be queried to determine if there is any locally stored response, and also determine whether the response is valid. When a valid response is available in the local cache **285**, the response can be provided to the application on the device **250** without the device **250** needing to access the cellular network or wireless broadband network.

If a valid response is not available, the local proxy **175** can query a remote proxy (e.g., the server proxy **125** of FIGS. **4**A-**4**C) to determine whether a remotely stored response is valid. If so, the remotely stored response (e.g., which may be stored on the server cache **135** or optional caching server **199** shown in the example of FIG. **1**C) can be provided to the mobile device, possibly without the mobile device **250** needing to access the cellular network, thus relieving consumption of network resources.

If a valid cache response is not available, or if cache responses are unavailable for the intercepted data request, the local proxy **175**, for example, the caching policy manager **245** can send the data request to a remote proxy (e.g., server proxy **125** of FIGS. **4**A-**4**C) which forwards the data request to a content source (e.g., application server/content provider **110** of FIG. **1**B) and a response from the content source can be provided through the remote proxy, as will be further described in the description associated with the example host server **100** of FIGS. **4**A-**4**C. The cache policy manager **245** can manage or process requests that use a variety of protocols, including but not limited to HTTP, HTTPS, IMAP, POP, SMTP, XMPP, and/or ActiveSync. The caching policy manager **245** can locally store responses for data requests in the local database **285** as cache entries for subsequent use in satisfying same or similar data requests.

The caching policy manager **245** can request that the remote proxy monitor responses for the data request and the remote proxy can notify the device **250** when an unexpected response to the data request is detected. In such an event, the cache policy manager **245** can erase or replace the locally stored response(s) on the device **250** when notified of the unexpected response (e.g., new data, changed data, additional data, etc.) to the data request. In one embodiment, the caching policy manager **245** is able to detect or identify the protocol used for a specific request, including but not limited to HTTP, HTTPS, IMAP, POP, SMTP, XMPP, and/or ActiveSync. In one embodiment, application specific handlers (e.g., via the application protocol module **246** of the caching policy manager **245**) on the local proxy **175** allows for optimization of any protocol that can be port mapped to a handler in the distributed proxy (e.g., port mapped on the proxy server **125** in the example of FIGS. **4**A-**4**C).

In one embodiment, the local proxy **175** notifies the remote proxy such that the remote proxy can monitor responses received for the data request from the content source for changed results prior to returning the result to the device **250**, for example, when the data request to the content source has yielded the same results to be returned to the mobile device. In general, the local proxy **175** can simulate application server responses for applications on the device **250**, using locally cached content. This can prevent utilization of the cellular network for transactions where new/changed data is not available, thus freeing up network resources and preventing network congestion.

In one embodiment, the local proxy **175** includes an application behavior detector **236** to track, detect, observe and/or monitor applications (e.g., proxy-aware and/or unaware applications **210** and **220**) accessed or installed on the device **250**. Application behaviors, or patterns in detected behaviors (e.g., via the pattern detector **237**) of one or more applications accessed on the device **250** can be used by the local proxy **175** to optimize traffic in a wireless network needed to satisfy the data needs of these applications.

For example, based on detected behavior of multiple applications, the traffic shaping engine **255** can align content requests made by at least some of the applications over the network (wireless network) (e.g., via the alignment module **256**). The alignment module **256** can delay or expedite some earlier received requests to achieve alignment. When requests are aligned, the traffic shaping engine **255** can utilize the connection manager to poll over the network to satisfy application data requests. Content requests for multiple applications can be aligned based on behavior patterns or rules/settings including, for example, content types requested by the multiple applications (audio, video, text, etc.), device (e.g., mobile or wireless device) parameters, and/or network parameters/traffic conditions, network service provider constraints/specifications, etc.

In one embodiment, the pattern detector **237** can detect recurrences in application requests made by the multiple applications, for example, by tracking patterns in application behavior. A tracked pattern can include, detecting that certain applications, as a background process, poll an application server regularly, at certain times of day, on certain days of the week, periodically in a predictable fashion, with a certain frequency, with a certain frequency in response to a certain type of event, in response to a certain type user query, frequency that requested content is the same, frequency with which a same request is made, interval between requests, applications making a request, or any combination of the above, for example.

Such recurrences can be used by traffic shaping engine **255** to offload polling of content from a content source (e.g., from an application server/content provider **110** of FIG. **1**A) that would result from the application requests that would be performed at the mobile device or wireless device **250** to be performed instead, by a proxy server (e.g., proxy server **125** of FIG. **1**C) remote from the device **250**. Traffic shaping engine **255** can decide to offload the polling when the recurrences match a rule. For example, there are multiple occurrences or requests for the same resource that have exactly the same content, or returned value, or based on detection of repeatable time periods between requests and responses such as a resource that is requested at specific times during the day. The offloading of the polling can decrease the amount of bandwidth consumption needed by the mobile device **250** to establish a wireless (cellular or other wireless broadband) connection with the content source for repetitive content polls.

As a result of the offloading of the polling, locally cached content stored in the local cache **285** can be provided to satisfy data requests at the device **250** when content change is not detected in the polling of the content sources. As such, when data has not changed, application data needs can be satisfied without needing to enable radio use or occupying cellular bandwidth in a wireless network. When data has changed and/or new data has been received, the remote entity (e.g., the host server) to which polling is offloaded, can notify the device **250**.

In one embodiment, the local proxy **175** can mitigate the need/use of periodic keep-alive messages (heartbeat messages) to maintain TCP/IP connections, which can consume significant amounts of power thus having detrimental impacts on mobile device battery life. The connection manager **265** in the local proxy (e.g., the heartbeat manager **267**) can detect, identify, and intercept any or all heartbeat (keep-alive) messages being sent from applications.

The heartbeat manager **267** can prevent any or all of these heartbeat messages from being sent over the cellular, or other network, and instead rely on the server component of the distributed proxy system (e.g., shown in FIG. **1**C) to generate and send the heartbeat messages to maintain a connection with the backend (e.g., application server/provider **110** in the example of FIG. **1**B).

In some embodiments, the traffic management policy manager **249** can manage and implement traffic management policies such as traffic blocking policies, delaying policies, transmission policies, and/or the like. The policy manager **249** may trigger certain policies when certain conditions are met or certain events occur. For example, traffic blocking and delaying policies may be enforced on low priority traffic when a radio of the mobile device is idle. During a period of enforcement for a given policy, traffic that matches the policy rule set may be impacted (e.g., temporarily blocked, permanently blocked, delayed, or the like). When the enforcement period ends, a radio connection may be established (e.g., via the connection manager **265**) and new connection requests may propagate across the network as usual. Any delayed or temporarily blocked traffic may be dispatched to their respective destinations in accordance with certain transmission policies, for example, which may come into effect when a predefined period of time expires or the radio of the mobile device comes up for other reasons (e.g., backlight turns on, user initiates a request, etc.).

In some embodiments, the radio state management engine **203** can perform the management and/or policy management of mobile device radio state promotion or demotion based on buffer, activity and/or device state monitoring. The radio state management engine **203** can determine what user activity and/or data activity should justify a radio state promotion and communicate the information to the network to be implemented as a single session, multi-session, or global policy (e.g., via a policy manager component on the network side proxy **114** of FIG. **3**. This policy can be used to execute the appropriate level of throttling to prevent the radio from going to higher powered states when unjustified based on dynamic conditions (e.g., network status, traffic, congestion, user expectations, user behavior, other activity, and the like).

In some embodiments, the radio state change notification manager **202** can monitor or track a radio state of the mobile device **250** and notify the network-side proxy **114** when the radio state is promoted to active. The notification can, for example, trigger the network-side proxy **114** to initiate transfer of delayed traffic to the mobile device **250**. In some other embodiments, the local proxy **175** may include a notification manager (not shown) that provides the network-side proxy **114** information on the mobile device state, user activity, application behavior, and the like. Such information may be utilized by the network-side proxy to intelligently manage incoming traffic at the network-side, and optimize signaling and conserve network and device resources.

The local proxy **175** generally represents any one or a portion of the functions described for the individual managers, modules, and/or engines. The local proxy **175** and device **250** can include additional or less components; more or less functions can be included, in whole or in part, without deviating from the novel art of the disclosure.

FIG. **2**B illustrates a block diagram depicting additional components in a user activity module and an application behavior detector shown in the example of FIG. **2**A.

One embodiment of the local proxy **175** includes the user activity module **215**, which further includes one or more of, a user activity detector/tracker **215***a*, a user activity prediction engine **215***b*, and/or a user expectation manager **215***c*. The application behavior detector **236** can further include a prioritization engine **241***a*, a time criticality detection engine **241***b*, an application state categorizer **241***c*, and/or an application traffic categorizer **241***d*. The local proxy **175** can further include a backlight detector **219**.

In one embodiment, the application behavior detector **236** may detect, determine, identify, or infer, the activity state of an application on the mobile device **250** from which traffic has originated or is directed to, for example, via the application state categorizer **241***c* and/or the application traffic categorizer **241***d*. The activity state can be determined based on whether the application is in a foreground or background state on the mobile device (via the application state categorizer **241***c*) since the traffic for a foreground application versus a background application may be handled differently.

In one embodiment, the activity state can be determined, detected, identified, or inferred with a level of certainty of heuristics, based on the backlight status of the mobile device **250** (e.g., by the backlight detector **219**) or other software agents or hardware sensors on the mobile device, including but not limited to, resistive sensors, capacitive sensors, ambient light sensors, motion sensors, touch sensors, and the like. In general, if the backlight is on, the traffic can be treated as being or determined to be generated from an application that is active or in the foreground, or the traffic is interactive. In addition, if the backlight is on, the traffic can be treated as being or determined to be traffic from user interaction or user activity, or traffic containing data that the user is expecting within some time frame.

In one embodiment, the activity state is determined based on whether the traffic is interactive traffic or maintenance traffic. Interactive traffic can include transactions from responses and requests generated directly from user activity/interaction with an application and can include content or data that a user is waiting or expecting to receive. Maintenance traffic may be used to support the functionality of an application which is not directly detected by a user. Maintenance traffic can also include actions or transactions that may take place in response to a user action, but the user is not actively waiting for or expecting a response.

For example, a mail or message delete action at a mobile device **250** generates a request to delete the corresponding mail or message at the server, but the user typically is not waiting for a response. Thus, such a request may be categorized as maintenance traffic, or traffic having a lower priority (e.g., by the prioritization engine **241***a*) and/or is not time-critical (e.g., by the time criticality detection engine **214***b*).

Contrastingly, a mail 'read' or message 'read' request initiated by a user a the mobile device **250**, can be categorized as 'interactive traffic' since the user generally is waiting to access content or data when they request to read a message or mail. Similarly, such a request can be categorized as having higher priority (e.g., by the prioritization engine **241***a*) and/or as being time critical/time sensitive (e.g., by the time criticality detection engine **241***b*).

The time criticality detection engine **241***b* can generally determine, identify, infer the time sensitivity of data contained in traffic sent from the mobile device **250** or to the mobile device from a host server (e.g., host **300**) or application server (e.g., app server/content source **110**). For example, time sensitive data can include, status updates, stock information updates, IM presence information, email messages or other messages, actions generated from mobile gaming applications, webpage requests, location updates, etc. Data that is not time sensitive or time critical, by nature of the content or request, can include requests to delete messages, mark-as-read or edited actions, application-specific actions such as an add-friend or delete-friend request, certain types of messages, or other information which does not frequently change by nature, etc. In some instances when the data is not time critical, the timing with which to allow the traffic to pass through is set based on when additional data needs to be sent from the mobile device **250**. For example, traffic shaping engine **255** can align the traffic with one or more subsequent transactions to be sent together in a single power-on event of the mobile device radio (e.g., using the alignment module **256** and/or the batching module **257**). The alignment module **256** can also align polling requests occurring close in time directed to the same host server, since these requests are likely to be responded to with the same data. In some instances, the timing for withholding or delaying traffic and timing for allowing any delayed or new traffic to the network can be based on traffic management policies.

In the alternate or in combination, the activity state can be determined from assessing, determining, evaluating, inferring, identifying user activity at the mobile device **250** (e.g., via the user activity module **215**). For example, user activity can be directly detected and tracked using the user activity tracker **215***a*. The traffic resulting therefrom can then be categorized appropriately for subsequent processing to determine the policy for handling. Furthermore, user activity can be predicted or anticipated by the user activity prediction engine **215***b*. By predicting user activity or anticipating user activity, the traffic thus occurring after the prediction can be treated as resulting from user activity and categorized appropriately to determine the transmission policy.

In addition, the user activity module **215** can also manage user expectations (e.g., via the user expectation manager **215***c* and/or in conjunction with the activity tracker **215** and/or the prediction engine **215***b*) to ensure that traffic is categorized appropriately such that user expectations are generally met. For example, a user-initiated action should be analyzed (e.g., by the expectation manager **215**) to determine or infer whether the user would be waiting for a response. If so, such traffic should be handled under a policy such that the user does not experience an unpleasant delay in receiving such a response or action.

In one embodiment, an advanced generation wireless standard network is selected for use in sending traffic between a mobile device and a host server in the wireless network based on the activity state of the application on the mobile device for which traffic is originated from or directed to. Advanced technology standards such as the 3G, 3.5G, 3G+, 4G, or LTE network can be selected for handling traffic generated as a result of user interaction, user activity, or traffic containing data that the user is expecting or waiting for. Advanced generation wireless standard network can also be selected for transmitting data contained in traffic directed to the mobile device which responds to foreground activities.

In categorizing traffic and defining a transmission policy for mobile traffic, a network configuration can be selected for use (e.g., by a network configuration selection engine) on the mobile device **250** in sending traffic between the mobile device and a proxy server and/or an application server (e.g., app server/host **110**). The network configuration that is selected can be determined based on information gathered by the application behavior module **236** regarding application activity state (e.g., background or foreground traffic), application traffic category (e.g., interactive or maintenance traffic), any priorities of the data/content, time sensitivity/criticality.

FIG. **3** illustrates a block diagram depicting an example of network-side components in a distributed proxy and cache system, including components for managing incoming traffic from third-party servers to enhance mobile traffic management in a mobile network and conserve resources.

In some embodiments, the network-side proxy **114** includes a radio state detector **302**, a policy manager module **304**, a traffic shaping engine **310** and a request/transaction manager **320**. The policy manager module **304** may further include a radio state policy manager **306**, a caching policy manager **307** and a traffic management policy manager **308**. The traffic shaping engine **310** may further include an alignment module **312**, a batching module **314** and/or a blocking module **316**. The request/transaction manager **320** may further include a time criticality detection engine **324**, a prioritization engine **326**, a traffic detector/categorizer **328**, an application state detector **330** and a device state detector **332**. More or less components may be present in the network-side proxy **114** and/or each illustrated component of the network-side proxy **114**.

One embodiment of the network-side proxy **114** includes a radio state detector **302** which tracks, detects, determines, estimates or receives information concerning radio states of mobile devices that connect to an operator's mobile network where the network-side proxy **114** resides. In some embodiments, the radio state detector **302** can be aware of radio states of mobile devices, and determine whether a mobile device is idle or active at any given time based on the traffic from mobile devices tunneling through the network-side proxy **114**. In embodiments where the network-side proxy **114** is integrated to the radio access network, the radio state detector **304** can be aware of the radio state of mobile devices based on information from the network. In other embodiments, the radio state detector **302** may obtain radio state information from the local proxy **175** and/or the proxy server **125** which can provide real time information on radio state promotions (e.g., transition from idle to active state) and demotions (e.g., transition from active to idle state). Receiving real time radio state information from the local proxy **175** and/or proxy server **125** could add bandwidth overhead. However, knowing the radio state information of a mobile device allows the network-side proxy **114** to manage incoming traffic in an efficient manner without having to cause the mobile device to turn on its radio every time data packets are received from third-party servers.

One embodiment of the network-side proxy **114** includes the request/transaction manager **320** which can detect, identify, intercept, process and/or manage incoming traffic initiated by third-party servers **110** as well as server responses (e.g., HTTP responses) to data requests from one or more applications on the mobile device **250**. The request/transaction manager **320** can determine how and when to process a given request or transaction, or a set of requests or transactions based on one or more criteria that may include, for example, transaction characteristics, network settings (e.g., inactivity or dormancy timers), and the like. In some embodiments, the transaction characteristics may depend on whether the transaction (e.g., HTTP response from third-party server) was a result of user-interaction or other user initiated action on the mobile device (e.g., user interaction with a mobile application), or if the transaction was initiated by the server (e.g., server-initiated data push). Transaction characteristics can also depend on the amount of data that will be transferred or is anticipated to be transferred as a result of the request/requested transaction.

In some embodiments, the request/transaction manager **320** can prioritize requests or transactions made by third-party servers and/or third-party server responses to requests made by applications on the mobile device **250** via the prioritization engine **326**, for example. Importance or priority of requests/transactions can be determined by the request/transaction manager by applying a rule set, for example, according to time sensitivity of the transaction, time sensitivity of the content in the transaction, time criticality of the transaction, time criticality of the data transmitted in the transaction, and/or time criticality or importance of an application to which the transmission is directed to. The time criticality of the transactions may be detected via the time criticality detection engine **324**. In general, a time critical transaction can include a transaction that is responsive to a user-initiated request, and can be prioritized as such. In some implementations, a time critical transaction is one that includes information having an expiry date/time (e.g., stock prices, weather, etc.) or information pertaining to applications whose operations or functions may be impaired if such information is delayed or blocked.

In general, the priorities can be determined or set in default, for example, based on device platform, device manufacturer, operating system, etc. Priorities can alternatively or in additionally be set by the particular application/server. For example, the Facebook mobile application/server can set its own priorities for various transactions (e.g., a status update can be of higher priority than an add friend request or a poke request; a message can be of higher priority than a notification of tagging), an email application/server or IM chat application/server may have its own configurations for priority. The prioritization engine **326** may include set of rules for assigning priority.

The prioritization engine **326** can also track network provider limitations or specifications on application or transaction priority in determining an overall priority status for a request/transaction. Furthermore, priority can in part or in whole be determined by user preferences, either explicit or implicit. A user, can in general, set priorities at different tiers, such as specific priorities for sessions, or types, or applications (e.g., a browsing session, a gaming session, versus an IM chat session, the user may set a gaming session to always have higher priority than an IM chat session, which may have higher priority than web-browsing session). A user can set application-specific priorities, (e.g., a user may set Facebook related transactions to have a higher priority than LinkedIn related transactions), for specific transaction types (e.g., for all send message requests across all applications to have higher priority than message delete requests, for all calendar-related events to have a high priority, etc.), and/or for specific folders.

The prioritization engine **326** can track and resolve conflicts in priorities set by different entities. For example, manual settings specified by the user may take precedence over device OS settings, network provider parameters/limitations (e.g., set in default for a network service area, geographic locale, set for a specific time of day, or set based on service/fee type) may limit any user-specified settings and/or application-set priorities. In some instances, data response to a manual sync request received from a user can override some, most, or all priority settings in that the requested synchronization is performed when requested, regardless of the individually assigned priority or an overall priority ranking for the requested action.

In some embodiments, the traffic categorizer **328** can analyze traffic from third-party servers and categorize such traffic as server-initiated traffic or server-response traffic, for example. The traffic categorizer **328** can, via the prioritization engine **326** and/or time criticality detection engine **324**, categorize traffic into priority-based categories (e.g., high, medium or low priority traffic). In some embodiments, the traffic categorizer **328** can further detect traffic from third-party servers relating to socket closures (e.g., FIN packets) or for checking if the client is still connected. Each categories of traffic may be handled in one or more ways by the network-side proxy **114** via the request/transaction manager **320**, traffic shaping engine **310**, and the like.

In some embodiments, the application state detector **330** detects the foreground or background state of applications on a mobile device **250** (e.g., using information reported by the local proxy **175** and/or the server proxy **125**). Information concerning the state of the applications may be used by the network-side proxy **114** to determine traffic from which third-party server(s) should be prioritized for transfer, for example. The device state detector **332**, in some embodiments, detects whether a mobile device is in active mode (e.g., back light is on or there is user interaction), or if the device is in an idle or passive mode (e.g., back light is off). Information relating to device state may be used in managing or shaping incoming traffic.

In some embodiments, the traffic shaping engine **310** may shape or manage server-initiated traffic and/or server response traffic. The traffic shaping engine **310** may utilize transaction characteristics, priority, time criticality, application state, radio state, traffic category, device state, and the like in shaping or managing traffic. For example, in one implementation, in response to determining that the radio state of a mobile device is idle, the traffic shaping engine **310** can delay low priority traffic from third-party servers at the network-side for a period of time, or until one or more conditions are met. For example, the network-side proxy **114** may continue to delay the low priority traffic until the radio state of the mobile device is promoted to a connected state.

One embodiment of the radio alignment module **312** of the traffic shaping engine **310** can align traffic from multiple third-party servers to optimize the number of radio turn on events and the amount of data that can be transferred to the mobile device in each radio event. In some instances, the optimization may not necessarily minimize the number of radio turn on events or maximize the amount of data that can be transferred per event since such optimization may also take into account other conditions or characteristics such as time criticality or urgency of some of the requests. For example, when an incoming request is time critical or high priority, the network-side proxy **114** can allow the radio on the mobile device to turn on so that the time critical or high priority incoming request can be transferred to the mobile device without delay.

The radio alignment module **312** can delay server initiated and/or server response traffic to achieve alignment with radio turn on events. When a radio turn on event is detected (e.g., via radio state detector **302**), the traffic shaping engine **310** can allow the delayed requests and/or responses to be transferred to the mobile device. In addition, the traffic shaping engine **310** can allow multiple low priority transactions from third-party servers to accumulate for batch transferring to a mobile device **250** (e.g., via the batching module **314**). The batching module **314** can initiate a batch transfer based on certain criteria. For example, a batch transfer of multiple occurrences of requests, some of which occurred at different instances in time, may occur after a certain number of low priority requests have been detected, after an amount of time elapses after the first of the low priority requests was initiated, or after an allocated buffer is filled. In addition, the batching module **314** can initiate a batch transfer of the accumulated low priority events when a higher priority event is received or detected at the network-side proxy **114**. A batch transfer can otherwise be initiated when radio use is triggered at the mobile device for another reason (e.g., user interaction wakes up the mobile device). In some embodiments, the batching capability can be disabled or enabled at the transaction level, application level, or session level, based on any one or combination of the following: user configuration, device limitations/settings, manufacturer specification, network operator parameters/limitations, platform specific limitations/settings, device OS settings, etc.

The traffic shaping engine **310**, in some embodiments, may also block some of the traffic from third-party servers that are determined to be unnecessary via the blocking module **316**. For example, when existing TCP sockets on a mobile device side are closed and the radio is down, a third-party server's socket may timeout and attempt to terminate the connection by sending a FIN packet or testing whether the connection is still alive by generating and sending some data. The blocking module **316** may block such unnecessary data packets from being delivered to the local proxy **175** of the mobile device **250**. In some embodiments, the network-side proxy **114** (via a caching policy manager **307**) may use a safe response (e.g., from cache **318**) to respond to the third party server to keep the server happy. In the example of the third-party server sending a FIN packet, the network-side proxy **114** via the caching policy manager **307** can respond with an ACK packet, which prevents the server TCP stack from making retry attempts, which usually incurs additional signaling.

One embodiment of the network-side proxy **114** includes a policy manager module **304**, which can manage policies relating to radio states, caching and/or traffic management. In one embodiment, the radio state policy manager **306** may perform the functions of a Policy and Charging Rules Function (PCRF) node in managing radio states of mobile devices by throttling. The radio state policy manager **306** determines whether a mobile device is idle or active at any given time (e.g., via the radio state detector **302**), and depending on this information, the radio state policy manager **306** can dictate whether components in the radio access network (e.g., eNodeB or Radio Network Controller (RNC)) implement policies that would, for example, allow or forbid a radio channel status upgrade into a higher powered state, or lower the radio channel status to a lower powered state in a more intelligent and resource efficient manner. In some embodiments, the radio state policy manager **306** can perform throttling and the local proxy **175** and/or the proxy server **125** can provide the information to the network regarding the level of throttling should occur to trigger radio state changes to higher powered or lower powered states. The PCRF, and details relating to promotion and demotion of radio states is described in detail in co-pending U.S. patent application Ser. No. 13/844,682 titled "Management of Mobile Device Radio State Promotion and Demotion," which is herein expressly incorporated by reference.

The caching policy manager **307**, in one embodiment, leverages data stored in the cache **318** to respond to incoming traffic or server response traffic, and thus obviate the need to establish a connection to a mobile device. The request/transaction manager **320** can intercept a request from a third-party server, and determine if there is a cached response in cache **318** that can be used as a response to the third-party server request. For example, in the case of a socket closure on the server-side, the network-side proxy **114** can respond with FIN/ACK, and prevent the server from attempting retries.

The traffic management policy manager **308** may also manage policies for coordinating, scheduling or aligning incoming and outgoing traffic and transmission of such traffic to their respective destinations. In one implementation, the traffic management policy manager **308** may implement a policy whereby both the local proxy **175** and the network-side proxy **114** delay or gate all the traffic during the same time period. When a trigger (e.g., based on a timer) is detected, network-side proxy **114** can promote the radio state of the mobile device to connected, and transfer the incoming traffic to the mobile device. Similarly, the local proxy **175** on the mobile device can take advantage of the radio state promotion from the network-side to transfer the outgoing traffic to the respective third-party servers. In some implementations, the radio state can be promoted from the device side due to other reasons (e.g., user initiating a request, backlight turning on). When the network-side proxy **114** detects the radio state promotion, the network-side proxy **114** can batch and transfer all the delayed traffic to the mobile device. When the radio state is demoted, the network-side proxy **114** (or the local proxy **175**) can restart the delay or gating timer to align the next set of incoming traffic.

FIG. **4**A depicts a block diagram illustrating an example of server-side components, in certain embodiments of a distributed proxy and cache system residing on a host server **400** that manages traffic in a wireless network (or broadband network) for resource conservation, content caching, and/or traffic management. In some embodiments, the server-side proxy (or proxy server **125**) can further categorize mobile traffic and/or deploy and/or implement policies such as traffic management and delivery policies based on device state, application behavior, content priority, user activity, and/or user expectations.

The host server **400** generally includes, for example, a network interface **408** and/or one or more repositories **412**, **414**, and **416**. Note that server **400** may be any portable/mobile or non-portable device, server, cluster of computers and/or other types of processing units (e.g., any number of a machine shown in the example of FIG. **1**B) able to receive or transmit signals to satisfy data requests over a network including any wired or wireless networks (e.g., WiFi, cellular, Bluetooth, etc.).

The network interface **408** can include networking module(s) or devices(s) that enable the server **400** to mediate data in a network with an entity that is external to the host server **400**, through any known and/or convenient communications protocol supported by the host and the external entity. Specifically, the network interface **408** allows the server **400** to communicate with multiple devices including mobile phone devices **450** and/or one or more application servers/content providers **410**.

The host server **400** can store information about connections (e.g., network characteristics, conditions, types of connections, etc.) with devices in the connection metadata repository **412**. Additionally, any information about third party application or content providers can also be stored in the repository **412**. The host server **400** can store information about devices (e.g., hardware capability, properties, device settings, device language, network capability, manufacturer, device model, OS, OS version, etc.) in the device information repository **414**. Additionally, the host server **400** can store information about network providers and the various network service areas in the network service provider repository **416**.

The communication enabled by network interface **408** allows for simultaneous connections (e.g., including cellular connections) with devices **450** and/or connections (e.g., including wired/wireless, HTTP, Internet connections, LAN, WiFi, etc.) with content servers/providers **410** to manage the traffic between devices **450** and content providers **410**, for optimizing network resource utilization and/or to conserver power (battery) consumption on the serviced devices **450**. The host server **400** can communicate with mobile devices **450** serviced by different network service providers and/or in the same/different network service areas. The host server **400** can operate and is compatible with devices **450** with varying types or levels of mobile capabilities, including by way of example but not limitation, 1G, 2G, 2G transitional (2.5G, 2.75G), 3G (IMT-2000), 3G transitional (3.5G, 3.75G, 3.9G), 4G (IMT-advanced), etc.

In general, the network interface **408** can include one or more of a network adaptor card, a wireless network interface card (e.g., SMS interface, WiFi interface, interfaces for various generations of mobile communication standards including but not limited to 1G, 2G, 3G, 3.5G, 4G type networks such as LTE, WiMAX, etc.), Bluetooth, WiFi, or any other network whether or not connected via a router, an access point, a wireless router, a switch, a multilayer switch, a protocol converter, a gateway, a bridge, a bridge router, a hub, a digital media receiver, and/or a repeater.

The host server **400** can further include server-side components of the distributed proxy and cache system which can include a proxy server **125** and a server cache **435**. In some embodiments, the proxy server **125** can include an HTTP access engine **445**, a caching policy manager **455**, a proxy controller **465**, a traffic shaping engine **375**, a new data detector **447** and/or a connection manager **495**.

The HTTP access engine **445** may further include a heartbeat manager **498**; the proxy controller **465** may further include a data invalidator module **468**; the traffic shaping engine **475** may further include a control protocol **476** and a batching module **477**. Additional or less components/modules/engines can be included in the proxy server **125** and each illustrated component.

In the example of a device (e.g., mobile device **450**) making an application or content request to an application server or content provider **410**, the request may be intercepted and routed to the proxy server **125** which is coupled to the device **450** and the application server/content provider **410**. Specifically, the proxy server is able to communicate with the local proxy (e.g., proxy **175** of the examples of FIG. **1**C) of the mobile device **450**, the local proxy forwards the data request to the proxy server **125** in some instances for further processing and, if needed, for transmission to the application server/content server **410** for a response to the data request.

In such a configuration, the host **400**, or the proxy server **125** in the host server **400** can utilize intelligent information provided by the local proxy in adjusting its communication with the device in such a manner that optimizes use of network and device resources. For example, the proxy server **125** can identify characteristics of user activity on the device **450** to modify its communication frequency. The characteristics of user activity can be determined by, for example, the activity/behavior awareness module **466** in the proxy controller **465** via information collected by the local proxy on the device **450**.

In some embodiments, communication frequency can be controlled by the connection manager **495** of the proxy server **125**, for example, to adjust push frequency of content or updates to the device **450**. For instance, push frequency can be decreased by the connection manager **495** when characteristics of the user activity indicate that the user is inactive. In some embodiments, when the characteristics of the user activity indicate that the user is subsequently active after a period of inactivity, the connection manager **495** can adjust the communication frequency with the device **450** to send data that was buffered as a result of decreased communication frequency to the device **450**.

In addition, the proxy server **125** includes priority awareness of various requests, transactions, sessions, applications, and/or specific events. Such awareness can be determined by the local proxy on the device **450** and provided to the proxy server **125**. The priority awareness module **467** of the proxy server **125** can generally assess the priority (e.g., including time-criticality, time-sensitivity, etc.) of various events or applications; additionally, the priority awareness module **467** can track priorities determined by local proxies of devices **450**.

In some embodiments, through priority awareness, the connection manager **495** can further modify communication frequency (e.g., use or radio as controlled by the radio controller **496**) of the server **400** with the devices **450**. For example, the server **400** can notify the device **450**, thus requesting use of the radio if it is not already in use when data or updates of an importance/priority level which meets a criteria becomes available to be sent.

In some embodiments, the proxy server **125** can detect multiple occurrences of events (e.g., transactions, content, data received from server/provider **410**) and allow the events to accumulate for batch transfer to device **450**. Batch transfer can be cumulated and transfer of events can be delayed based on priority awareness and/or user activity/application behavior awareness as tracked by modules **467** and/or **466**. For example, batch transfer of multiple events (of a lower priority) to the device **450** can be initiated by the batching module **477** when an event of a higher priority (meeting a threshold or criteria) is detected at the server **400**. In addition, batch transfer from the server **400** can be triggered when the server receives data from the device **450**, indicating that the device radio is already in use and is thus on. In some embodiments, the proxy server **125** can order the each messages/packets in a batch for transmission based on event/transaction priority such that higher priority content can be sent first in case connection is lost or the battery dies, etc.

In some embodiments, the server **400** caches data (e.g., as managed by the caching policy manager **455**) such that communication frequency over a network (e.g., cellular network) with the device **450** can be modified (e.g., decreased). The data can be cached, for example, in the server cache **435** for subsequent retrieval or batch sending to the device **450** to potentially decrease the need to turn on the device **450** radio. The server cache **435** can be partially or wholly internal to the host server **400**, although in the example of FIG. **5**A it is shown as being external to the host **400**. In some instances, the server cache **435** may be the same as and/or integrated in part or in whole with another cache managed by another entity (e.g., the optional caching proxy server **199** shown in the example of FIG. **1**C), such as being managed by an application server/content provider **410**, a network service provider, or another third party.

In some embodiments, content caching is performed locally on the device **450** with the assistance of host server **400**. For example, proxy server **125** in the host server **400** can query the application server/provider **410** with requests and monitor changes in responses. When changed or new responses are detected (e.g., by the new data detector **447**), the proxy server **125** can notify the mobile device **450** such that the local proxy on the device **450** can make the decision to invalidate (e.g., indicated as out-dated) the relevant cache entries stored as any responses in its local cache. Alternatively, the data invalidator module **468** can automatically instruct the local proxy of the device **450** to invalidate certain cached data, based on received responses from the application server/provider **410**. The cached data is marked as invalid, and can get replaced or deleted when new content is received from the content server **410**.

Note that data change can be detected by the detector **447** in one or more ways. For example, the server/provider **410** can notify the host server **400** upon a change. The change can also be detected at the host server **400** in response to a direct poll of the source server/provider **410**. In some instances, the proxy server **125** can in addition, pre-load the local cache on the device **450** with the new/updated data. This can be performed when the host server **400** detects that the radio on the mobile device is already in use, or when the server **400** has additional content/data to be sent to the device **450**.

One or more the above mechanisms can be implemented simultaneously or adjusted/configured based on application (e.g., different policies for different servers/providers **410**). In some instances, the source provider/server **410** may notify the host **400** for certain types of events (e.g., events meeting a priority threshold level). In addition, the provider/server **410** may be configured to notify the host **400** at specific time intervals, regardless of event priority.

In some embodiments, the proxy server **125** of the host **400** can monitor/track responses received for the data request from the content source for changed results prior to returning the result to the mobile device, such monitoring may be suitable when data request to the content source has yielded same results to be returned to the mobile device, thus preventing network/power consumption from being used when no new changes are made to a particular requested. The local proxy of the device **450** can instruct the proxy server **125** to perform such monitoring or the proxy server **125** can automatically initiate such a process upon receiving a certain number of the same responses (e.g., or a number of the same responses in a period of time) for a particular request.

In some embodiments, the server **400**, through the activity/behavior awareness module **466**, is able to identify or detect user activity at a device that is separate from the mobile device **450**. For example, the module **466** may detect that a user's message inbox (e.g., email or types of inbox) is being accessed. This can indicate that the user is interacting with his/her application using a device other than the mobile device **450** and may not need frequent updates, if at all.

The server **400**, in this instance, can thus decrease the frequency with which new or updated content is sent to the mobile device **450**, or eliminate all communication for as long as the user is detected to be using another device for access. Such frequency decrease may be application specific (e.g., for the application with which the user is interacting with on another device), or it may be a general frequency decrease (e.g., since the user is detected to be interacting with one server or one application via another device, he/she could also use it to access other services.) to the mobile device **450**.

In some embodiments, the host server **400** is able to poll content sources **410** on behalf of devices **450** to conserve power or battery consumption on devices **450**. For example, certain applications on the mobile device **450** can poll its respective server **410** in a predictable recurring fashion. Such recurrence or other types of application behaviors can be tracked by the activity/behavior module **466** in the proxy controller **465**. The host server **400** can thus poll content sources **410** for applications on the mobile device **450** that would otherwise be performed by the device **450** through a wireless (e.g., including cellular connectivity). The host server can poll the sources **410** for new or changed data by way of the HTTP access engine **445** to establish HTTP connection or by way of radio controller **496** to connect to the source **410** over the cellular network. When new or changed data is detected, the new data detector **447** can notify the device **450** that such data is available and/or provide the new/changed data to the device **450**.

In some embodiments, the connection manager **495** determines that the mobile device **450** is unavailable (e.g., the radio is turned off) and utilizes SMS to transmit content to the device **450**, for instance, via the SMSC shown in the example of FIG. **1**C. SMS is used to transmit invalidation messages, batches of invalidation messages, or even content in the case where the content is small enough to fit into just a few (usually one or two) SMS messages. This avoids the need to access the radio channel to send overhead information. The host server **400** can use SMS for certain transactions or responses having a priority level above a threshold or otherwise meeting a criteria. The server **400** can also utilize SMS as an out-of-band trigger to maintain or wake-up an IP connection as an alternative to maintaining an always-on IP connection.

In some embodiments, the connection manager **495** in the proxy server **125** (e.g., the heartbeat manager **498**) can generate and/or transmit heartbeat messages on behalf of connected devices **450** to maintain a backend connection with a provider **410** for applications running on devices **450**.

For example, in the distributed proxy system, local cache on the device **450** can prevent any or all heartbeat messages needed to maintain TCP/IP connections required for applications from being sent over the cellular, or other, network and instead rely on the proxy server **125** on the host server **400** to generate and/or send the heartbeat messages to maintain a connection with the backend (e.g., application server/provider **110** in the example of FIG. **1**B). The proxy server can generate the keep-alive (heartbeat) messages independent of the operations of the local proxy on the mobile device.

The repositories **412**, **414**, and/or **416** can additionally store software, descriptive data, images, system information, drivers, and/or any other data item utilized by other components of the host server **400** and/or any other servers for operation. The repositories may be managed by a database management system (DBMS), for example, which may be but is not limited to Oracle, DB2, Microsoft Access, Microsoft SQL Server, PostgreSQL, MySQL, FileMaker, etc.

The repositories can be implemented via object-oriented technology and/or via text files and can be managed by a distributed database management system, an object-oriented database management system (OODBMS) (e.g., ConceptBase, FastDB Main Memory Database Management System, JDOInstruments, ObjectDB, etc.), an object-relational database management system (ORDBMS) (e.g., Informix, OpenLink Virtuoso, VMDS, etc.), a file system, and/or any other convenient or known database management package.

FIG. **4**B depicts a block diagram illustrating a further example of components in a caching policy manager **455** in the distributed proxy and cache system shown in the example of FIG. **4**A which is capable of caching and adapting caching strategies for mobile application behavior and/or network conditions.

The caching policy manager **455**, In some embodiments, can further include a metadata generator **403**, a cache look-up engine **405**, an application protocol module **456**, a content source monitoring engine **457** having a poll schedule manager **458**, a response analyzer **461**, and/or an updated or new content detector **459**. In some embodiments, the poll schedule manager **458** further includes a host timing simulator **458***a*, a long poll request detector/manager **458***b*, a schedule update engine **458***c*, and/or a time adjustment engine **458***d*. The metadata generator **403** and/or the cache look-up engine **405** can be coupled to the cache **435** (or, server cache) for modification or addition to cache entries or querying thereof.

In some embodiments, the proxy server (e.g., the proxy server **125** of the examples of FIGS. **1**B-**1**C and FIG. **4**A) can monitor a content source for new or changed data via the monitoring engine **457**. The proxy server, as shown, is an entity external to the mobile device **250** of FIGS. **2**A-**2**B. The content source (e.g., application server/content provider **110** of FIG. **1**B-**1**C) can be one that has been identified to the proxy server (e.g., by the local proxy) as having content that is being locally cached on a mobile device (e.g., mobile device **150** or **250**). The content source can be monitored, for example, by the monitoring engine **457** at a frequency that is based on polling frequency of the content source at the mobile device. The poll schedule can be generated, for example, by the local proxy and sent to the proxy server. The poll frequency can be tracked and/or managed by the poll schedule manager **458**.

For example, the proxy server can poll the host (e.g., content provider/application server) on behalf of the mobile device and simulate the polling behavior of the client to the host via the host timing simulator **458***a*. The polling behavior can be simulated to include characteristics of a long poll request-response sequences experienced in a persistent connection with the host (e.g., by the long poll request detector/manager **458***b*). Note that once a polling interval/behavior is set, the local proxy **175** on the device-side and/or the proxy server **125** on the server-side can verify whether application and application server/content host behavior match or can be represented by this predicted pattern. In general, the local proxy and/or the proxy server can detect deviations and, when appropriate, re-evaluate and compute, determine, or estimate another polling interval.

In some embodiments, the caching policy manager **455** on the server-side of the distribute proxy can, in conjunction with or independent of the proxy server **175** on the mobile device, identify or detect long poll requests. For example, the caching policy manager **455** can determine a threshold value to be used in comparison with a response delay interval time in a request-response sequence for an application request to identify or detect long poll requests, possible long poll requests (e.g., requests for a persistent connection with a host with which the client communicates including, but not limited to, a long-held HTTP request, a persistent connection enabling COMET style push, request for HTTP streaming, etc.), or other requests which can otherwise be treated as a long poll request.

For example, the threshold value can be determined by the proxy **125** using response delay interval times for requests generated by clients/applications across mobile devices which may be serviced by multiple different cellular or wireless networks. Since the proxy **125** resides on host **400** is able to communicate with multiple mobile devices via multiple networks, the caching policy manager **455** has access to application/client information at a global level which can be used in setting threshold values to categorize and detect long polls.

By tracking response delay interval times across applications across devices over different or same networks, the caching policy manager **455** can set one or more threshold values to be used in comparison with response delay interval times for long poll detection. Threshold values set by the proxy server **125** can be static or dynamic, and can be associated with conditions and/or a time-to-live (an expiration time/date in relative or absolute terms).

In addition, the caching policy manager **455** of the proxy **125** can further determine the threshold value, in whole or in part, based on network delays of a given wireless network, networks serviced by a given carrier (service provider), or multiple wireless networks. The proxy **125** can also determine the threshold value for identification of long poll requests based on delays of one or more application server/content provider (e.g., **110**) to which application (e.g., mobile application) or mobile client requests are directed.

The proxy server can detect new or changed data at a monitored content source and transmits a message to the mobile device notifying it of such a change such that the mobile device (or the local proxy on the mobile device) can take appropriate action (e.g., to invalidate the cache elements in the local cache). In some instances, the proxy server (e.g., the caching policy manager **455**) upon detecting new or changed data can also store the new or changed data in its cache (e.g., the server cache **135** of the examples of FIG. **1**C). The new/updated data stored in the server cache **435** can be used in some instances to satisfy content requests at the mobile device; for example, it can be used after the proxy server has notified the mobile device of the new/changed content and that the locally cached content has been invalidated.

The metadata generator **403** can generate metadata for responses cached for requests at the mobile device **250**. The metadata generator **403** can generate metadata for cache entries stored in the server cache **435**. Similarly, the cache look-up engine **405** can include the same or similar functions are those described for the cache look-up engine **205** shown in the example of FIG. **4**B.

The response analyzer **461** can perform any or all of the functionalities related to analyzing responses received for requests generated at the mobile device **250** in the same or similar fashion to the response analyzer **246***d* of the local proxy shown in the example of FIG. **4**B. Since the proxy server **125** is able to receive responses from the application server/content source **410** directed to the mobile device **250**, the proxy server **125** (e.g., the response analyzer **461**) can perform similar response analysis steps to determine cacheability, as described for the response analyzer of the local proxy. The responses can be analyzed in addition to or in lieu of the analysis that can be performed at the local proxy **175** on the mobile device **250**.

Furthermore, the schedule update engine **458***c* can update the polling interval of a given application server/content host based on application request interval changes of the application at the mobile device **250** as described for the schedule update engine in the local proxy **175**. The time adjustment engine **458***d* can set an initial time at which polls of the application server/content host is to begin to prevent the serving of out of date content once again before serving fresh content as described for the schedule update engine in the local proxy **175**. Both the schedule updating and the time adjustment algorithms can be performed in conjunction with or in lieu of the similar processes performed at the local proxy **175** on the mobile device **250**.

FIG. **4**C depicts a block diagram illustrating examples of additional components in certain embodiments in a proxy server **125** shown in the example of FIG. **4**A which is further capable of performing mobile traffic categorization and policy implementation based on application behavior and/or traffic priority to enhance mobile traffic management and resource conservation in a mobile network.

In some embodiments of the proxy server **125**, the traffic shaping engine **475** is further coupled to a traffic analyzer **436** for categorizing mobile traffic for policy definition and implementation for mobile traffic and transactions directed to one or more mobile devices (e.g., mobile device **250** of FIGS. **2**A-C) or to an application server/content host (e.g., **110** of FIGS. **1**B-**1**C). In general, the proxy server **125** is remote from the mobile devices and remote from the host server, as shown in the examples of FIGS. **1**B-**1**C. The proxy server **125** or the host server **400** can monitor the traffic for multiple mobile devices and is capable of categorizing traffic and devising traffic policies for different mobile devices.

In addition, the proxy server **125** or host server **400** can operate with multiple carriers or network operators and can implement carrier-specific policies relating to categorization of traffic and implementation of traffic policies for the various categories. For example, the traffic analyzer **436** of the proxy server **125** or host server **400** can include one or more of, a prioritization engine **441***a*, a time criticality detection engine **441***b*, an application state categorizer **441***c*, and/or an application traffic categorizer **441***d*.

Each of these engines or modules can track different criterion for what is considered priority, time critical, background/foreground, or interactive/maintenance based on different wireless carriers. Different criterion may also exist for different mobile device types (e.g., device model, manufacturer, operating system, etc.). In some instances, the user of the mobile devices can adjust the settings or criterion regarding traffic category and the proxy server **125** is able to track and implement these user adjusted/configured settings.

In some embodiments, the traffic analyzer **436** is able to detect, determined, identify, or infer, the activity state of an application on one or more mobile devices (e.g., mobile device **150** or **250**) which traffic has originated from or is directed to, for example, via the application state categorizer **441***c* and/or the traffic categorizer **441***d*. The activity state can be determined based on whether the application is in a foreground or background state on one or more of the mobile devices (via the application state categorizer **441***c*) since the traffic for a foreground application vs. a background application may be handled differently to optimize network use.

In the alternate or in combination, the activity state of an application can be determined by the wirelessly connected mobile devices (e.g., via the application behavior detectors in the local proxies) and communicated to the proxy server **125**. For example, the activity state can be determined, detected, identified, or inferred with a level of certainty of heuristics, based on the backlight status at mobile devices (e.g., by a backlight detector) or other software agents or hardware sensors on the mobile device, including but not limited to, resistive sensors, capacitive sensors, ambient light sensors, motion sensors, touch sensors, etc. In general, if the backlight is on, the traffic can be treated as being or determined to be generated from an application that is active or in the foreground, or the traffic is interactive. In addition, if the backlight is on, the traffic can be treated as being or determined to be traffic from user interaction or user activity, or traffic containing data that the user is expecting within some time frame.

The activity state can be determined from assessing, determining, evaluating, inferring, identifying user activity at the mobile device **250** (e.g., via the user activity module **215**) and communicated to the proxy server **125**. In some embodiments, the activity state is determined based on whether the traffic is interactive traffic or maintenance traffic. Interactive traffic can include transactions from responses and requests generated directly from user activity/interaction with an application and can include content or data that a user is waiting or expecting to receive. Maintenance traffic may be used to support the functionality of an application which is not directly detected by a user. Maintenance traffic can also include actions or transactions that may take place in response to a user action, but the user is not actively waiting for or expecting a response.

The time criticality detection engine **441***b* can generally determine, identify, infer the time sensitivity of data contained in traffic sent from the mobile device **250** or to the mobile device from the host server **400** or proxy server **125**, or the application server (e.g., app server/content source **110**). For example, time sensitive data can include, status updates, stock information updates, IM presence information, email messages or other messages, actions generated from mobile gaming applications, webpage requests, location updates, etc.

Data that is not time sensitive or time critical, by nature of the content or request, can include requests to delete messages, mark-as-read or edited actions, application-specific actions such as an add-friend or delete-friend request, certain types of messages, or other information which does not frequently changing by nature, etc. In some instances when the data is not time critical, the timing with which to allow the traffic to be sent to a mobile device is based on when there is additional data that needs to the sent to the same mobile device. For example, traffic shaping engine **475** can align the traffic with one or more subsequent transactions to be sent together in a single power-on event of the mobile device radio (e.g., using the alignment module **478** and/or the batching module **477**). The alignment module **478** can also align polling requests occurring close in time directed to the same host server, since these request are likely to be responded to with the same data.

In general, whether new or changed data is sent from a host server to a mobile device can be determined based on whether an application on the mobile device to which the new or changed data is relevant, is running in a foreground (e.g., by the application state categorizer **441***c*), or the priority or time criticality of the new or changed data. The proxy server **125** can send the new or changed data to the mobile device if the application is in the foreground on the mobile device, or if the application is in the foreground and in an active state interacting with a user on the mobile device, and/or whether a user is waiting for a response that would be provided in the new or changed data. The proxy server **125** (or traffic shaping engine **475**) can send the new or changed data that is of a high priority or is time critical.

Similarly, the proxy server **125** (or the traffic shaping engine **475**) can suppressing the sending of the new or changed data if the application is in the background on the mobile device. The proxy server **125** can also suppress the sending of the new or changed data if the user is not waiting for the response provided in the new or changed data; wherein the suppressing is performed by a proxy server coupled to the host server and able to wirelessly connect to the mobile device.

In general, if data, including new or change data is of a low priority or is not time critical, the proxy server can waiting to transfer the data until after a time period, or until there is additional data to be sent (e.g. via the alignment module **478** and/or the batching module **477**).

FIG. **5**A illustrates a logic flow diagram of an example method for aligning incoming and outgoing traffic by delaying all traffic (incoming and outgoing) to match an interval that both the local proxy **175** and the network-side proxy **114** agree on. In the example method, at block **502**, the local proxy **175** and/or the network-side proxy **114** configures an interval for delaying all incoming and outgoing traffic. In some implementations, the interval may be based on a policy that is enforced by the local proxy **175** and/or the network-side proxy **114**. The policy can be distributed by the server-side proxy **125** or the operator of the mobile network. At block **504**, the local proxy **175** on a mobile device delays all outgoing traffic from mobile applications to match the configured interval for incoming and outgoing traffic. At block **506**, the network-side proxy **114**, in the operator network, delays any or all incoming traffic from third-party servers directed towards the mobile device to match the configured interval for incoming and outgoing traffic. When the interval expires (e.g., as determined by a timer), as determined at block **508**, the radio on the mobile device is promoted to an active state or an otherwise higher powered state. For example, the radio on the mobile device can be promoted from IDLE to CELL_DCH state, where CELL_DCH is a high power state with high throughput and power consumption. By way of another example, the radio on the mobile device can be promoted from CELL_FACH, a low power state with low throughput and power consumption to CELL_DCH state. The local proxy **175** then transfers the delayed outgoing traffic from the mobile device to respective third-party servers, while the network-side proxy **114** transfers the delayed incoming traffic from one or more third-party servers to the mobile device at block **510**. Even if the interval is not expired but the mobile device radio is on for other reasons as determined at decision block **512**, the incoming or outgoing traffic can be transferred to their respective destinations. When the interval has not expired, and when the radio state of the mobile device is in idle or otherwise in a low power state, the local proxy on the mobile device can continue to delay outgoing traffic at the mobile device at block **504**, and the network-side proxy **114** can also continue to delay incoming traffic at the network-side proxy **114** at block **506**.

FIG. **5**B illustrates a logic flow diagram of an example method for delaying and/or blocking incoming traffic. As illustrated, the network-side proxy **114** monitors incoming traffic from third-party servers at block **520** to determine whether the incoming traffic should be delayed, blocked or delivered to a mobile device. At block **522**, the network-side proxy **114** tracks or monitors mobile device state, application state and/or user behavior. For example, the network-side proxy **114** can track the mobile device state (e.g., idle or connected), backlight status (on or off), and the like. The network-side proxy **114** can also determine the application state (e.g., foreground or background), application use information (e.g., how frequently or recently an application is used), and the like. The network-side proxy **114** can further determine user behavior information such as the whether the user is interacting with an application, behavioral patterns (e.g., frequency and/or timing of user interaction with the mobile device and/or application), and the like. By way of another example, the network-side proxy **114** can also be aware of traffic received from third-party servers in response to data requests from the mobile device after the inactivity timer has expired.

At block **524**, the network-side proxy **114** categorizes the incoming traffic according to urgency or time criticality, priority, and the like. The network-side proxy **114** can also determine whether the incoming traffic is unnecessary. In one embodiment, data relating to socket closures or data relating to testing of a connection, acknowledgements, and the like can be considered unnecessary when a radio on the mobile device is in idle state or in some cases, regardless of the radio state. Unnecessary data can include any date that can be safely blocked without adverse consequences, including impact on user experience or functionality of mobile applications and/or the mobile device. For example, if a third-party server sends a FIN packet to terminate a TCP connection when a radio on the mobile device is idle, the FIN packet can be categorized as unnecessary data, since it can be safely blocked without adverse consequences. Further, such blocking of unnecessary data eliminates the need to power on the radio on the mobile device and reduces signaling in the mobile network.

In an embodiment, the network-side proxy **114** can use mobile device, application and/or user behavior to categorize the incoming traffic, and refrain from transferring some of the incoming traffic to the mobile device, even if the radio on the mobile device is on. By way of an example, if the mobile device's radio is on or is in a certain state, and there is interactive traffic associated with a bandwidth heavy application (e.g., YouTube, Skype), the incoming traffic having lower priority may be delayed to prioritize the incoming interactive traffic associated with the application on the foreground of the mobile device.

At decision block **526**, the network-side proxy **114** determines whether the mobile device's radio is on, and if so, the network-side proxy **114** transfers the incoming traffic from one or more third-party servers to the mobile device at block **527**. If the radio on the mobile device is down, at decision block **528**, the network-side proxy **114** determines whether the incoming traffic from one or more third-party servers meets one or more criteria for blocking. Such blocking criteria may include, for example, availability of cached response, whether the incoming traffic is unnecessary, and the like. The criteria for blocking may be specified by traffic management policies, in an embodiment. For example, if the network-side proxy **114** determines that the incoming traffic from a third-party server is unnecessary, the network-side proxy **114** blocks the unnecessary incoming traffic at block **530**. Similarly, if the network-side proxy **114** determines that a request in the incoming traffic can be responded to using a cached response, the network-side proxy **114** blocks the incoming traffic at block **530**, and provides the cached response to the server that initiated the request at block **532**. Alternately, if the incoming traffic does not meet the one or more criteria for blocking, the network-side proxy determines whether the incoming traffic meets one or more criteria for delaying at decision block **534**. The delaying criteria may be based on category of the incoming traffic including priority or urgency, time criticality, or criticality relating to the functioning of an application and/or the mobile device, and the like. Such delaying criteria may be established by the traffic management policies, for example.

If the incoming traffic meets the criteria for delaying (e.g., incoming traffic is low priority traffic as described in reference to the prioritization engine **326**, the time criticality detection engine **324** or the traffic categorizer **328**), the incoming traffic is delayed at block **540**, and the network-side proxy **114** continues to monitor the incoming traffic at block **520**. Alternately, if the incoming traffic does not meet the criteria for delaying (e.g., the incoming traffic is time critical), then the network-side proxy may initiate or trigger paging of the mobile device to activate the radio on the mobile device at block **536**. At block **538**, the network-side proxy **114** can transfer the incoming traffic and any other delayed traffic to the mobile device over the established radio connection.

FIG. **5**C illustrates a logic flow diagram of an example method for batch transferring delayed requests/responses from the network-side proxy **114** to a mobile device **250**. At block **550**, the network-side proxy **114** delays requests and/or responses from third-party servers that meet one or more delay criteria, which can include device state, application state, user behavior, time of day, day of the week, application type, category of the requests and/or responses, network settings (e.g., inactivity timer expiry), and the like. In some embodiments, the delay criteria can be specified by traffic management policies. At block **552**, the network-side proxy **114** can block some of the requests and/or responses from the third-party servers that meet one or more blocking criteria. At block **553**, the network-side proxy **114** can provide cached responses to some of the requests from the third-party servers. At block **554**, the network-side proxy **114** detects a trigger to send the delayed requests/responses to a mobile device. The trigger can include, for example, a change in the radio state of the mobile device (e.g., radio state promotion to active or high power state), screen of the mobile device turning on, detecting of user interaction, receiving of a request/response having high priority, size of the aggregated delayed requests, and the like. At block **556**, the network-side proxy **114** initiates a batch transfer of the delayed requests and/or responses to the mobile device. In some embodiments, the network-side proxy can signal the mobile device to turn on the radio or up the power of the radio to allow batch transfer of some or all of the delayed requests and/or responses from the network-side proxy **114** to the mobile device.

FIG. **6** depicts a table **600** showing examples of different traffic or application category types which can be used enhancing mobile traffic management. For example, traffic/application categories can include interactive or background, whether a user is waiting for the response, foreground/background application, and whether the backlight is on or off.

FIG. **7** depicts a table **700** showing examples of different content category types which can be used for enhancing mobile traffic management. For example, content category types can include content of high or low priority, and time critical or non-time critical content/data.

FIG. **8** shows a diagrammatic representation of a machine in the example form of a computer system within which a set of instructions, for causing the machine to perform any one or more of the methodologies discussed herein, may be executed.

In the example of FIG. **8**, the computer system **800** includes a processor, memory, non-volatile memory, and an interface device. Various common components (e.g., cache memory) are omitted for illustrative simplicity. The computer system **800** is intended to illustrate a hardware device on which any of the components depicted in the example of FIGS. **2**A-**2**B, **3** and **4**A-**4**C (and any other components described in this specification) can be implemented. The computer system **800** can be of any applicable known or convenient type. The components of the computer system **800** can be coupled together via a bus or through some other known or convenient device.

The processor may be, for example, a conventional microprocessor such as an Intel Pentium microprocessor or

Motorola power PC microprocessor. One of skill in the relevant art will recognize that the terms "machine-readable (storage) medium" or "computer-readable (storage) medium" include any type of device that is accessible by the processor.

The memory is coupled to the processor by, for example, a bus. The memory can include, by way of example but not limitation, random access memory (RAM), such as dynamic RAM (DRAM) and static RAM (SRAM). The memory can be local, remote, or distributed.

The bus also couples the processor to the non-volatile memory and drive unit. The non-volatile memory is often a magnetic floppy or hard disk, a magnetic-optical disk, an optical disk, a read-only memory (ROM), such as a CD-ROM, EPROM, or EEPROM, a magnetic or optical card, or another form of storage for large amounts of data. Some of this data is often written, by a direct memory access process, into memory during execution of software in the computer **800**. The non-volatile storage can be local, remote, or distributed. The non-volatile memory is optional because systems can be created with all applicable data available in memory. A typical computer system will usually include at least a processor, memory, and a device (e.g., a bus) coupling the memory to the processor.

Software is typically stored in the non-volatile memory and/or the drive unit. Indeed, for large programs, it may not even be possible to store the entire program in the memory. Nevertheless, it should be understood that for software to run, if necessary, it is moved to a computer readable location appropriate for processing, and for illustrative purposes, that location is referred to as the memory in this paper. Even when software is moved to the memory for execution, the processor will typically make use of hardware registers to store values associated with the software, and local cache that, ideally, serves to speed up execution. As used herein, a software program is assumed to be stored at any known or convenient location (from non-volatile storage to hardware registers) when the software program is referred to as "implemented in a computer-readable medium." A processor is considered to be "configured to execute a program" when at least one value associated with the program is stored in a register readable by the processor.

The bus also couples the processor to the network interface device. The interface can include one or more of a modem or network interface. It will be appreciated that a modem or network interface can be considered to be part of the computer system. The interface can include an analog modem, isdn modem, cable modem, token ring interface, satellite transmission interface (e.g. "direct PC"), or other interfaces for coupling a computer system to other computer systems. The interface can include one or more input and/or output devices. The I/O devices can include, by way of example but not limitation, a keyboard, a mouse or other pointing device, disk drives, printers, a scanner, and other input and/or output devices, including a display device. The display device can include, by way of example but not limitation, a cathode ray tube (CRT), liquid crystal display (LCD), or some other applicable known or convenient display device. For simplicity, it is assumed that controllers of any devices not depicted in the example of FIG. **8** reside in the interface.

In operation, the computer system **800** can be controlled by operating system software that includes a file management system, such as a disk operating system. One example of operating system software with associated file management system software is the family of operating systems known as Windows® from Microsoft Corporation of Redmond, Wash., and their associated file management systems. Another example of operating system software with its associated file management system software is the Linux operating system and its associated file management system. The file management system is typically stored in the non-volatile memory and/or drive unit and causes the processor to execute the various acts required by the operating system to input and output data and to store data in the memory, including storing files on the non-volatile memory and/or drive unit.

Some portions of the detailed description may be presented in terms of algorithms and symbolic representations of operations on data bits within a computer memory. These algorithmic descriptions and representations are the means used by those skilled in the data processing arts to most effectively convey the substance of their work to others skilled in the art. An algorithm is here, and generally, conceived to be a self-consistent sequence of operations leading to a desired result. The operations are those requiring physical manipulations of physical quantities. Usually, though not necessarily, these quantities take the form of electrical or magnetic signals capable of being stored, transferred, combined, compared, and otherwise manipulated. It has proven convenient at times, principally for reasons of common usage, to refer to these signals as bits, values, elements, symbols, characters, terms, numbers, or the like.

It should be borne in mind, however, that all of these and similar terms are to be associated with the appropriate physical quantities and are merely convenient labels applied to these quantities. Unless specifically stated otherwise as apparent from the following discussion, it is appreciated that throughout the description, discussions utilizing terms such as "processing" or "computing" or "calculating" or "determining" or "displaying" or the like, refer to the action and processes of a computer system, or similar electronic computing device, that manipulates and transforms data represented as physical (electronic) quantities within the computer system's registers and memories into other data similarly represented as physical quantities within the computer system memories or registers or other such information storage, transmission or display devices.

The algorithms and displays presented herein are not inherently related to any particular computer or other apparatus. Various general purpose systems may be used with programs in accordance with the teachings herein, or it may prove convenient to construct more specialized apparatus to perform the methods of some embodiments. The required structure for a variety of these systems will appear from the description below. In addition, the techniques are not described with reference to any particular programming language, and various embodiments may thus be implemented using a variety of programming languages.

In alternative embodiments, the machine operates as a standalone device or may be connected (e.g., networked) to other machines. In a networked deployment, the machine may operate in the capacity of a server or a client machine in a client-server network environment, or as a peer machine in a peer-to-peer (or distributed) network environment.

The machine may be a server computer, a client computer, a personal computer (PC), a tablet PC, a laptop computer, a set-top box (STB), a personal digital assistant (PDA), a cellular telephone, an iPhone, a Blackberry, a processor, a telephone, a web appliance, a network router, switch or bridge, or any machine capable of executing a set of instructions (sequential or otherwise) that specify actions to be taken by that machine.

While the machine-readable medium or machine-readable storage medium is shown in an exemplary embodiment to be a single medium, the term "machine-readable medium" and "machine-readable storage medium" should be taken to include a single medium or multiple media (e.g., a centralized or distributed database, and/or associated caches and servers) that store the one or more sets of instructions. The term "machine-readable medium" and "machine-readable storage medium" shall also be taken to include any medium that is capable of storing, encoding or carrying a set of instructions for execution by the machine and that cause the machine to perform any one or more of the methodologies of the presently disclosed technique and innovation.

In general, the routines executed to implement the embodiments of the disclosure, may be implemented as part of an operating system or a specific application, component, program, object, module or sequence of instructions referred to as "computer programs." The computer programs typically comprise one or more instructions set at various times in various memory and storage devices in a computer, and that, when read and executed by one or more processing units or processors in a computer, cause the computer to perform operations to execute elements involving the various aspects of the disclosure.

Moreover, while embodiments have been described in the context of fully functioning computers and computer systems, those skilled in the art will appreciate that the various embodiments are capable of being distributed as a program product in a variety of forms, and that the disclosure applies equally regardless of the particular type of machine or computer-readable media used to actually effect the distribution.

Further examples of machine-readable storage media, machine-readable media, or computer-readable (storage) media include but are not limited to recordable type media such as volatile and non-volatile memory devices, floppy and other removable disks, hard disk drives, optical disks (e.g., Compact Disk Read-Only Memory (CD ROMS), Digital Versatile Disks, (DVDs), etc.), among others, and transmission type media such as digital and analog communication links.

Unless the context clearly requires otherwise, throughout the description and the claims, the words "comprise," "comprising," and the like are to be construed in an inclusive sense, as opposed to an exclusive or exhaustive sense; that is to say, in the sense of "including, but not limited to." As used herein, the terms "connected," "coupled," or any variant thereof, means any connection or coupling, either direct or indirect, between two or more elements; the coupling of connection between the elements can be physical, logical, or a combination thereof. Additionally, the words "herein," "above," "below," and words of similar import, when used in this application, shall refer to this application as a whole and not to any particular portions of this application. Where the context permits, words in the above Detailed Description using the singular or plural number may also include the plural or singular number respectively. The word "or," in reference to a list of two or more items, covers all of the following interpretations of the word: any of the items in the list, all of the items in the list, and any combination of the items in the list.

The above detailed description of embodiments of the disclosure is not intended to be exhaustive or to limit the teachings to the precise form disclosed above. While specific embodiments of, and examples for, the disclosure are described above for illustrative purposes, various equivalent modifications are possible within the scope of the disclosure, as those skilled in the relevant art will recognize. For example, while processes or blocks are presented in a given order, alternative embodiments may perform routines having steps, or employ systems having blocks, in a different order, and some processes or blocks may be deleted, moved, added, subdivided, combined, and/or modified to provide alternative or subcombinations. Each of these processes or blocks may be implemented in a variety of different ways. Also, while processes or blocks are at times shown as being performed in series, these processes or blocks may instead be performed in parallel, or may be performed at different times. Further any specific numbers noted herein are only examples: alternative implementations may employ differing values or ranges.

The teachings of the disclosure provided herein can be applied to other systems, not necessarily the system described above. The elements and acts of the various embodiments described above can be combined to provide further embodiments.

Any patents and applications and other references noted above, including any that may be listed in accompanying filing papers, are incorporated herein by reference. Aspects of the disclosure can be modified, if necessary, to employ the systems, functions, and concepts of the various references described above to provide yet further embodiments of the disclosure.

These and other changes can be made to the disclosure in light of the above Detailed Description. While the above description describes certain embodiments of the disclosure, and describes the best mode contemplated, no matter how detailed the above appears in text, the teachings can be practiced in many ways. Details of the system may vary considerably in its implementation details, while still being encompassed by the subject matter disclosed herein. As noted above, particular terminology used when describing certain features or aspects of the disclosure should not be taken to imply that the terminology is being redefined herein to be restricted to any specific characteristics, features, or aspects of the disclosure with which that terminology is associated. In general, the terms used in the following claims should not be construed to limit the disclosure to the specific embodiments disclosed in the specification, unless the above Detailed Description section explicitly defines such terms. Accordingly, the actual scope of the disclosure encompasses not only the disclosed embodiments, but also all equivalent ways of practicing or implementing the disclosure under the claims.

While certain aspects of the disclosure are presented below in certain claim forms, the inventors contemplate the various aspects of the disclosure in any number of claim forms. For example, while only one aspect of the disclosure is recited as a means-plus-function claim under 35 U.S.C. §112, ¶6, other aspects may likewise be embodied as a means-plus-function claim, or in other forms, such as being embodied in a computer-readable medium. (Any claims intended to be treated under 35 U.S.C. §112, ¶6 will begin with the words "means for".) Accordingly, the applicant reserves the right to add additional claims after filing the application to pursue such additional claim forms for other aspects of the disclosure.

The invention claimed is:

1. A method for mobile traffic management on a mobile carrier or mobile operator, comprising:

delaying, at a proxy server, a batch of transactions initiated by an application server directed towards a mobile device until a predetermined transfer time period,

wherein the application server is associated with a mobile application on the mobile device;

wherein, a batch of transactions originating from the mobile application on the mobile device is delayed;

detecting arrival of a trigger that includes a message of high priority, time critical, or an urgent transaction directed to the mobile device and initiated by the application server;

transferring, at the proxy server, the message associated with the trigger to the mobile device in response to detecting the trigger;

wherein, in response to transferring the message associated with the trigger, the batched transactions originating from the mobile application are transferred to the proxy server and the batched transactions initiated by the application server continue to be delayed until the predetermined transfer time period,

wherein the proxy server is associated with or residing on the mobile carrier or the mobile operator.

2. The method of claim **1**, wherein the delaying is in response to determining that a radio on the mobile device is in idle state.

3. The method of claim **1**, wherein the transactions initiated by the application server are delayed to achieve radio alignment between the proxy server where the transactions are buffered and the mobile device.

4. The method of claim **1**, wherein the proxy server resides in a core network or a radio access network.

5. The method of claim **1**, wherein the transactions that were delayed include low priority, non-time critical or non-urgent transactions.

6. The method of claim **1**, wherein the transactions that were delayed include a response from the application server received in response to a request from the mobile device, wherein the response from the application server was received after expiration of an inactivity timer of a mobile network and after demotion of a radio on the mobile device to an idle state.

7. The method of claim **1**, wherein the transactions that were delayed are transferred to the mobile device over a single connection established between the mobile device and a mobile network.

8. The method of claim **1**, wherein the trigger includes a start of an interval for transferring the transactions that were delayed from the proxy server to the mobile device.

9. The method of claim **8**, wherein transactions initiated from one or more mobile applications on the mobile device are transferred over a mobile network to respective application servers during the same interval.

10. The method of claim **2**, wherein the trigger includes promotion of the radio on the mobile device from the idle state to an active state or from a low power state to a high power state.

11. The method of claim **10**, wherein the promotion of the radio on the mobile device is responsive to turning on of a screen of the mobile device.

12. The method of claim **1**, further comprising:

intercepting a transaction initiated by an application server associated with a mobile application on the mobile device;

identifying the transaction as being unnecessary;

blocking the transaction identified as being unnecessary to prevent establishment of a radio link between the mobile device and a mobile network.

13. The method of claim **1**, further comprising:

intercepting a transaction initiated by an application server associated with a mobile application on the mobile device;

determining whether a cached response is available for responding to the transaction;

if so, providing the cached response as a response to the transaction to prevent establishment of a radio link between the mobile device and a mobile network.

14. A system for enhancing mobile traffic management, comprising:

a proxy server integrated to a mobile network or a core network to enforce a mobile traffic management policy configured to:

intercept and delay a batch of transactions initiated from multiple application servers associated with multiple mobile applications on a mobile device until a predetermined transfer time period;

detect arrival of a trigger that includes a message of high priority, time critical, or an urgent transaction directed to the mobile device and initiated by the application server;

transfer the message associated with the trigger to the mobile device in response to detecting the trigger; and

in response to transferring the message associated with the trigger, receive the batched transactions originating from the mobile application, wherein the batch of transactions initiated by the application servers continues to be delayed until the predetermined transfer time period, wherein the batched transactions initiated by an application server continue to be delayed until the predetermined transfer time period.

15. The system of claim **14**, wherein the transactions were delayed in response to determining that a radio on the mobile device is in idle state.

16. The system of claim **14**, wherein the transactions were delayed to achieve radio alignment between the proxy server where the transactions were buffered and the mobile device.

17. The system of claim **14**, wherein the transactions include low priority, non-time critical or non-urgent transactions and wherein the transactions that were delayed are transferred to the mobile device over a single connection established between the mobile device and the mobile network.

18. The system of claim **14**, wherein the transactions include a response to a request from the mobile device that is received from one of the multiple application servers after expiration of a network dormancy timer.

19. The system of claim **14**, wherein the trigger includes a start of an interval for transferring the transactions that were delayed from the proxy server to the mobile device, wherein transactions initiated from multiple mobile applications on the mobile device are transferred to respective application servers during the same interval.

20. The system of claim **15**, wherein the trigger includes promotion of the radio on the mobile device from the idle state to an active state.

21. The system of claim **20**, wherein the promotion of the radio on the mobile device is responsive to turning on of a screen of the mobile device or detection of user activity at the mobile device.

22. The system of claim **14**, wherein the proxy server is further configured to:

intercept a transaction initiated by an application server associated with a mobile application on the mobile device;

identify the transaction as being unnecessary;

block the transaction identified as unnecessary to prevent establishment of a radio link between the mobile device and the mobile network.

23. The system of claim **14**, wherein the proxy server is further configured to:

intercept a transaction initiated by an application server associated with a mobile application on the mobile device;

determine whether a cached response is available for responding to the transaction;

if so, provide the cached response as a response to the transaction to prevent establishment of a radio link between the mobile device and the mobile network.

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